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PROJECT COMPLETION REPORT

BENTHIC COMMUNITY DYNAMICS IN RELATION TO SEDIMENTARY REHABILITATION ON TRIBUTARIES OF THE SOUTH FORK OF THE SALMON RIVER

Cooperative Agreement, USFS, Salmon River Study

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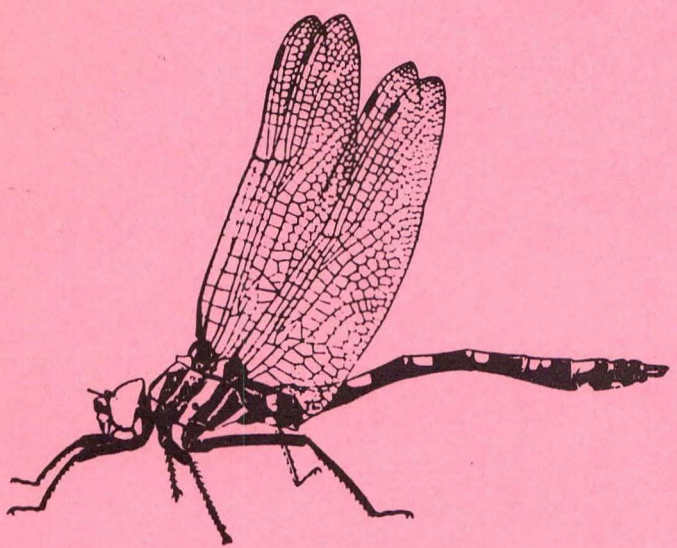

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
DESCRIPTION OF AREA	4
METHODS AND MATERIALS	9
A. Field Study	9
Station Descriptions	9
Station Quadrant Design	9
Station Morphometrics	10
Hydrology	10
Sediment Classification	10
Transect Analysis	11
Core Sample Analysis	11
Benthic Sampling and Community Analysis	14
Bottom Sampling Technique	14
Basket Sampling Technique	14
Canister Sampling Technique	15
Drift Sampling Technique	16
Community Similarity and Cluster Analysis	17
B. Laboratory Study	18
Insect Substrate Colonization	18
Insect Vertical Distribution	19
RESULTS	21
A. Field Study	21
Physical Stream Characteristics	21
Flow	21

Page

Substrate..... 21

Benthic Community Analysis..... 34

Intensive Study Sites..... 34

Community Similarity..... 40

Faunistic Benthos Analysis..... 46

Benthic Community Regression Analysis..... 50

Basket Analysis..... 54

Canister Analysis..... 54

Drift Analysis..... 68

B. Laboratory Study..... 77

Drift Simulation Analysis..... 77

Canister Analysis..... 80

DISCUSSION..... 81

A. Insect-sediment Associations..... 81

Substrate Dynamics..... 81

Insect Behavorial Response to Changing Substrate Conditions..... 85

B. Stream Rehabilitation Practices and Biological Implications..... 90

SUMMARY..... 94

RECOMMENDATIONS 97

LITERATURE CITED..... 99

APPENDICES..... 104

A. 104

B. 107

C. 110

Page

D. 113

E. 114

F. 115

G. 116

H. 118

LIST OF TABLES

Table		Page
1.	Summary of tributary location, development and channel morphometrics.	8
2.	Surface sediment classification of dominant substrate.	12
3.	Surface sediment classification of imbeddedness of cobble.	12
4.	Mean monthly and annual discharge (cfs) near Krassel Ranger Station on South Fork of the Salmon River, Idaho.	22
5.	Station Morphometrics and flow for late summer 1972, 1973 and 1974 for Trail, Dollar and Blackmare Creeks. .	26
6.	Substrate rank means and statistical comparisons for dominant substrate, surrounding material and imbeddedness (Duncan's Multiple Range Test) for intensive study stations for 1973-74.	31
7.	Sediment core analysis of percent finer material for quadrants (A,B,C,D) and station averages for Trail, Dollar and Blackmare Creeks, 1972.	33
8.	Diversity, redundancy, density (No./m^2) and number of species for six intensive study stations for summer and fall, 1972-1974..	35
9.	Diversity, redundancy, number of species, density and averages for "faunistic" stations of Dollar Creek (D_a - D_e) for summer and fall, 1972-1974.	49
10.	Correlation coefficients and associated probabilities comparing density and diversity with dominant substrate, imbeddedness, material surrounding cobble and water depth..	52
11.	Regression coefficients, T values and probability values comparing density and diversity with dominant substrate, imbeddedness, material surrounding cobble and water depth.	53

Table Page

12. Diversity, redundancy and number of species for baskets at "faunistic" sites (D_a - D_e) on Dollar Creek, 1972-1974. 57

13. Density, numbers of species, and diversity and redundancy averages for canisters at intensive study sites for summer 1973. 63

14. Density, numbers of species, and diversity and redundancy averages for canisters at intensive study sites for fall 1973. 64

15. Density, numbers of species, and diversity and redundancy averages for canisters at intensive study sites for Winter: 1973-74 and Summer-1974. . . 65

16. Selected species found in canister levels (T=top, M=middle, B=bottom) at intensive study sites (Stations 1-6) during five consecutive sampling periods: Spring-1973, Fall-1973, Winter: 1973-74 and Summer-1974. 66

17. Sediment analysis for three canister levels (top, middle, bottom) in Trail (1), Dollar (3) and Blackmare (5) Creeks. 69

18. Sediment analysis for three canister levels (top, middle, bottom) in the St. Maries River. 70

19. Insect drift for Trail (T) and Blackmare (B) Creeks expressed as numbers/m^3, number of species, diversity redundancy and total numbers for Ephemeroptera, Plecoptera, Trichoptera, Diptera and Coleoptera, 1972-74. 72

LIST OF FIGURES

Figure		Page
1.	A portion of the South Fork Salmon River drainage indicating location of the study area, intensive and "faunistic" study sites..	5
2.	Location of study area and Idaho Batholith region.	6
3.	Vertical sampling canister and streambed core sampler shown inserted into streambed.	13
4.	Mean monthly discharge (cfs) for 1972-73, 1973-74 and eight year average near the Krassel Ranger Station on the South Fork Salmon River, Idaho. Water year= October 1 to September 30.	23
5.	Average discharge (cfs) per water year from 1966 to 1974 for the South Fork Salmon River near Krassel Ranger Station, Idaho. Water year = October 1 to September 30.	24
6.	Stream profiles for upper Trail Creek (Station 1) and lower Trail Creek (Station 2) for 1972, 1973 and 1974.	27
7.	Stream profile for upper Dollar Creek (Station 3) and lower Dollar Creek (Station 4) for 1972, 1973 and 1974.	28
8.	Stream profile for upper Blackmare Creek (Station 5) and lower Blackmare Creek (Station 6) for 1972, 1973 and 1974.	29
9.	Diversity, redundancy, number of species and density for Trail and Dollar Creeks, 1972-1974.	37
10.	Diversity, redundancy, number of species and density for Blackmare Creek, 1972-1974.	38
11.	Diversity, redundancy, number of species and density for Station 1 and Station 2 on Trail Creek, 1972-74..	41
12.	Diversity, redundancy, number of species and density for Station 3 and Station 4 on Dollar Creek, 1972-74.	42

Figure Page

13. Diversity, redundancy, number of species and density for Station 5 and Station 6 on Blackmare Creek, 1972-74. 43

14. Average percent total species and percent total numbers for summer bottom samples from intensive study stations. 44

15. Average percent total species and percent total numbers for fall bottom samples from intensive study stations. 45

16. Community similarity and cluster analysis for summer (S) and fall (F) samples in Trail (T), Dollar (D) and Blackmare (B) Creeks (Stations 1-6) in 1972, 1973 and 1974. 47

17. Bottom sample diversity, redundancy, numbers of species and density at "faunistic stations" for fall, 1972 and summer and fall, 1973-74. 48

18. Regression relationships for diversity (A-D) and density (E-H) per bottom sample in relation to ranked cobble imbeddedness, dominant substrate, sediment surrounding cobble and water depth. 51

19. Average percent total species and percent total numbers for basket samples from intensive study stations.. 55

20. Average percent total species and percent total numbers for basket samples from "faunistic" sites on Dollar Creek. 56

21. Numbers of insects per canister level (T, top; M, middle; B, bottom) and ordinal percent contribution at intensive study stations (1-6) from June 27, 1973 to July 18, 1973 (Summer 1973 sample) 59

22. Numbers of insects per canister level (T, top; M, middle; B, bottom) and ordinal percent contribution at intensive study stations (1-6) from July 18, 1973 to September 5, 1973 (Fall-1973 sample). . 60

Figure Page

23. Numbers of insects per canister level (T, top; M, middle; B, bottom) and ordinal percent contribution at intensive study stations (1,3,5) from September 5, 1973 to May 5, 1974 (Winter: 1973-74 sample). 61

24. Numbers of insects per canister level (T, top; M, middle; B, bottom) and ordinal percent contribution at intensive study stations (1,4,5) from July 8, 1974 to September 10, 1974 (Summer-1974 sample). 62

25. Insect drift for A. Trail and B. Blackmare Creeks for 1972 indicating a. total numbers, b. total density (numbers/m^3), c. numbers of Baetis tricaudatus Dodds and d. numbers of Epeorus grandis (McDun.). . . 74

26. Insect drift for A. Trail and B. Blackmare Creeks for 1973 indicating a. total numbers, b. total density (numbers/m^3), c. numbers of Chironomidae and d. numbers of Baetis tricaudatus Dodds. . . . 75

27. Insect drift for A. Trail and B. Blackmare Creeks for 1974 indicating a. total numbers, b. total density (numbers/m^3), c. numbers of Epeorus albertae (McDun.), d. numbers of Epeorus grandis (McDun.), and e. numbers of Baetis bicaudatus Dodds. 76

28. Percent colonization/channel quadrants and percent drifting from the channel for A. Acroneuria californica (Banks), B. Pteronarcella sp. and C. Ephemerella grandis Eaton when subjected to moderately sedimented and unsedimented conditions. . . 78

29. Laboratory canister simulation with percent present at each level (t, top; m, middle; b, bottom) using Acroneuria sp. (A,D,E), Ephemerella flavilinea McDun. (B) and A-Acroneuria sp. and R-Rhyacophila acropedes Banks combined (C). 79

ABSTRACT

Three tributary streams, Trail, Dollar and Blackmare Creeks, of the South Fork Salmon River Idaho were selected to evaluate insect habitats and colonization capabilities during and after watershed rehabilitation from 1972 to 1974.

Sediment core samples were obtained from tributary streambeds to determine substrate composition. Physical parameters of cobble size, cobble imbeddedness, sediment surrounding cobble and water depth were obtained along line transects to evaluate stream profile dynamics.

Aquatic insect communities were sampled and correlated with each physical parameter noted above. Vertical sampling canisters were used to evaluate insect communities within the streambed. Basket samples were taken to compare insect communities between streams. Insect drift was measured on Trail and Blackmare Creeks. Laboratory simulations were conducted to evaluate the effects of sediment on insect behavior.

Substrate values for the tributary streams were similar during the study. Gravel and sand were dominant sediments. Benthic insect communities were similar for the tributary streams. Blackmare Creek demonstrated greatest benthic stability. Mayflies generally dominated the upper levels of the hyporheic zone; stoneflies and caddisflies dominated the lower strata. Insect drift was similar for Trail and Blackmare Creeks. Basket samples showed little variation in insect communities between streams. Insect communities inhabiting the South Fork tributaries were dynamic and capable of adapting to changing flows and substrate conditions. Watershed rehabilitation is viewed as being

more practical than instream rehabilitation for long-term stabilizing effects.

INTRODUCTION

In recent years much concern has centered on measuring the impact of man-caused perturbation on stream ecosystems. Practical management practices for streams have been greatly hampered by the lack of knowledge of the ecological resiliency of these systems. Base-line information integrating biotic and abiotic factors of complex lotic system is needed to provide intelligent preservation, manipulation and rehabilitation of our streams.

The South Fork Salmon River represents one of the most aesthetic and economically important drainages in Idaho. Its economic value has been historically based upon a multi-million dollar fishery, timber production and grazing. This drainage formerly supported one of Idaho's largest summer-run races of chinook salmon. Many reaches had ideal spawning beds. Hundreds of high-elevation, coldwater streams are found transecting the rugged terrain. The South Fork, a major tributary of the Salmon River, is a long narrow drainage which embraces elevations varying from approximately 9,000 feet (2744 m) at the headwaters to approximately 3,700 feet (1128 m) near its confluence with the main Salmon River. The South Fork Salmon River drainage lies entirely within the Idaho Batholith, an area which presents many resource management problems.

The unique geology of this area and its affects on the aquatic environment has drawn much attention to the South Fork in the last two decades. Decomposed granitic-based soil presents a special problem to

the aquatic environment and life in the streams. The loose, fragile soil, typical of the batholith region, creates problems of erosion, stream sedimentation, and land-cover instability. These problems have been compounded in the past by logging, road construction and grazing. As a result of these activities, the aquatic environment of the South Fork Salmon River has been degraded.

A special survey was made by the U. S. Forest Service in 1966-67 to evaluate the volume of accumulated sediments and assess its affects on the aquatic environment. Findings from this study stimulated a rehabilitation program on the South Fork Salmon River to reduce the volume of sediments in the river (Mickelson et al., 1973). The findings of that study led subsequently to the curtailment of logging operations and road construction. Because of a delay in funding for the rehabilitation work, stabilization techniques were not implemented until 1971. During the time-lag from 1967 to 1971, reanalysis of the problem was made. Results indicated that instream sediment volumes had been reduced by an estimated 40 percent (Mickelson et al., 1973). Natural stabilization and environmental resiliency was thus considered an important asset in planing for total rehabilitation.

The Forest Service now concludes that with continued stabilization techniques such as seeding old logging roads, cross barring, ditching and removing culverts, coupled with discontinued logging practices, the South Fork Salmon River can restore itself to a near-natural condition (Mickelson et al., 1973).

The Department of Entomology, University of Idaho in cooperation with the U. S. Forest Service initiated a study in the spring of 1972 to: 1) evaluate aquatic insect habitats through changing community

structure during and after watershed rehabilitation; 2) study recolonization capabilities of aquatic insects; and 3) to qualitatively and quantitatively enumerate aquatic insect populations in relation to a watershed rehabilitation program initiated in 1971-72.

DESCRIPTION OF AREA

The South Fork Salmon River is located in West-Central Idaho and is a principal tributary to the main Salmon River (Fig. 1). The upper reaches of the South Fork, extending from the headwaters to the confluence of the East Fork of the South Fork of the Salmon River, drains approximately 254,000 acres and yields an average of one million acre feet of water annually (Mickelson et al., 1973). The headwaters of the South Fork originate in the Boise National Forest and join the East Fork of the South Fork in the Payette National Forest. The topography is moderate to steep with slopes of 40 to 65% common. Vegetation is of three primary types: sage brush and grass along the ridge tops; Ponderosa pine (Pinus ponderosa Dougl.) on south facing slopes; and lodgepole pine (Pinus contorta Dougl.) and Douglas fir (Pseudotsuga menziesii (Poir.) Britt.) on the cooler north slopes (Mickelson et al., 1973). Top soil is shallow and course textured overlying granitic bedrock.

The batholith region formed when granite and related rock formations cooled and solidified at considerable depths within the earth. The granite has since been uplifted and exposed with the original surface rocks eroded away (Ross and Savage, 1967). As a result of the cooling process, temperature fluctuations, mineral content and age, large granitic intrusions exist, and extend over a 16,000 square-mile (41,600 sq. kilometers) area in Idaho (Fig. 2). This unique batholith soil is subject to extreme erosion when subjected to natural or man-caused disturbance in steep, mountainous terrain. Batholith soils developed from decomposed granite and exhibit textures ranging from

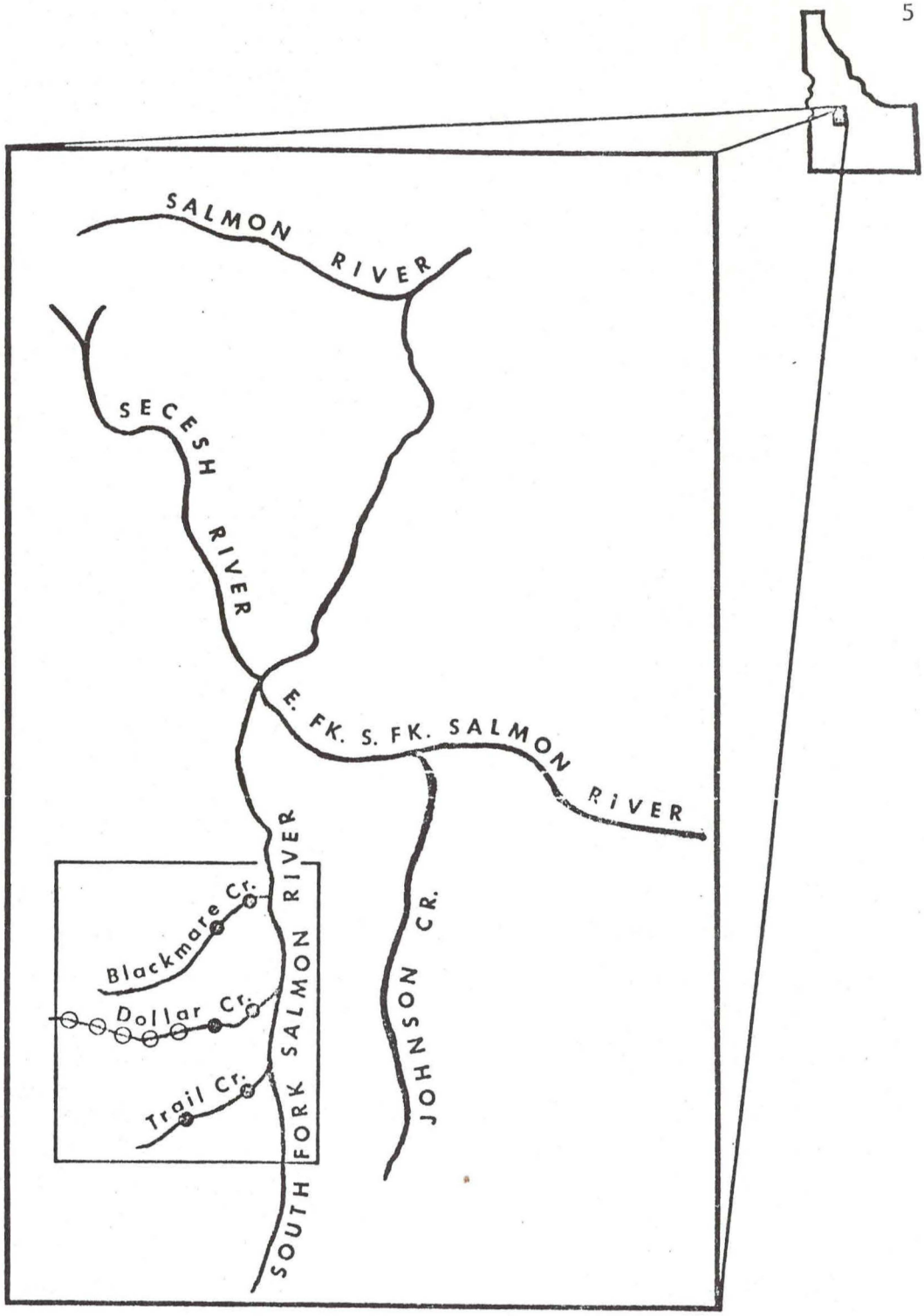

Fig. 1 A portion of the South Fork Salmon River drainage indicating location of the study area, intensive (●) and "faunistic" (○) study sites. (Modified from Platts, 1974).

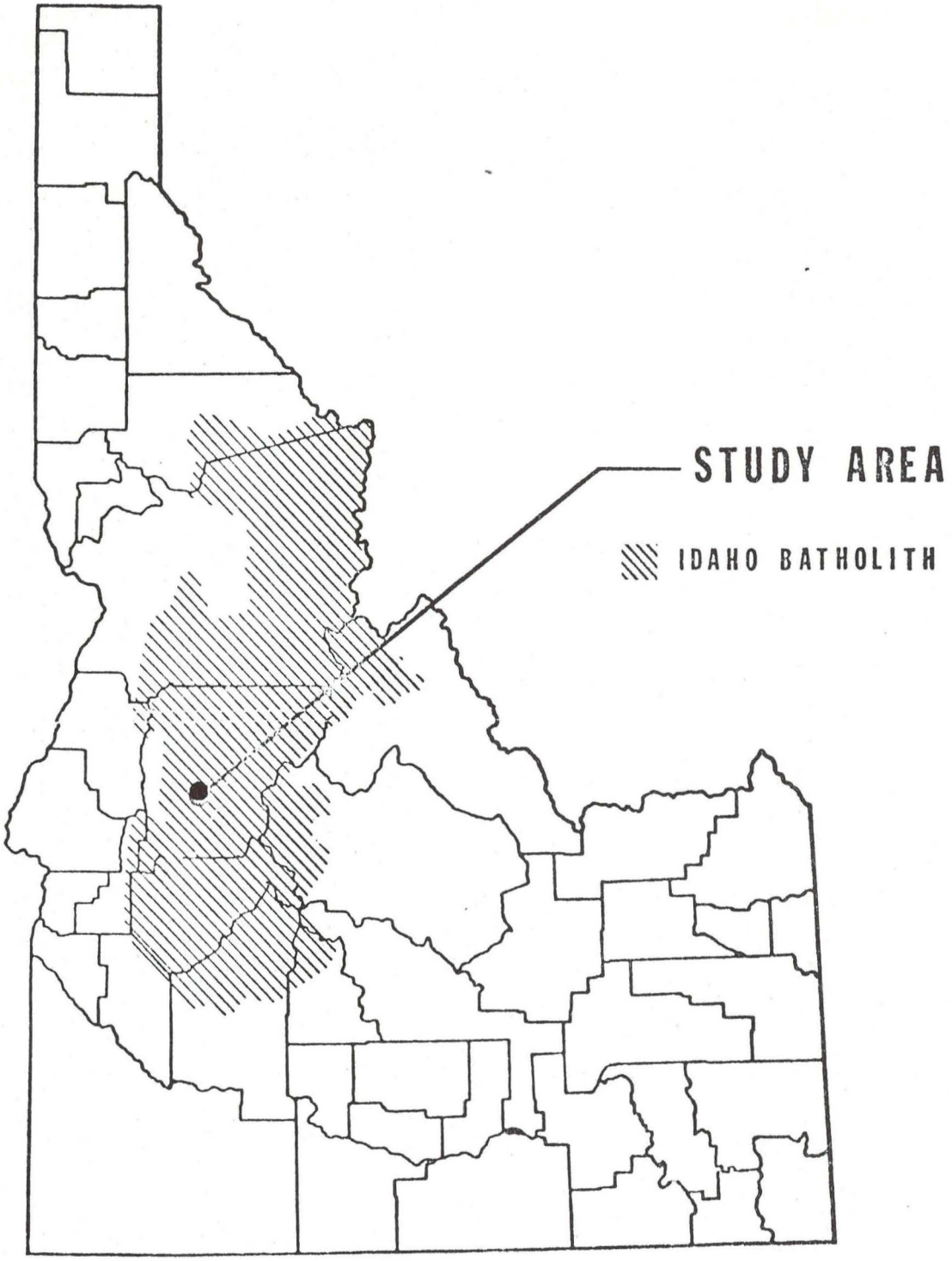

Fig. 2. Location of study area and Idaho Batholith region.

loamy sand to sandy loam (Megahan, 1972). Silt and clay content is low thus little cohesion is found within the substrate.

Average mean precipitation in the South Fork drainage is 36" (90 cm), of which 45-90% falls as snow. Frontal storms during winter and spring produce as much as 10" (25.4 cm) of precipitation in a one to four-hour period, a critical factor in flooding and landslides (Mickelson et al., 1973).

The South Fork Salmon River is too large and deep for conventional sampling in most reaches. Thus, three tributary streams, Trail, Dollar and Blackmare Creeks were selected for intensive study to reflect bio-physical changes (Table 1). These tributaries average 5,672 ft (1,730 m) in elevation and are high-elevation, coldwater streams. Trail and Dollar Creeks were selected because both drainages had been extensively logged and were heavy sediment producers. Blackmare Creek was pristine, having no past, unnatural disturbances in the drainage.

The lower reaches of most tributary streams support chinook salmon for spawning and rearing while the upper and middle reaches are usually dominated by rainbow trout.

Table 1. Summary of tributary location, development and channel morphometrics. (Data in part provided by Platts, 1974).

Morphometric Character	Trail Cr. Boise Nat. Forest	Dollar Cr. Boise Nat. Forest	Blackmare Cr. Payette Nat. Forest
Av. Length	2.5 mi (4.0 km)	2.8 mi (4.5 km)	3.8 mi (6.1 km)
Av. Width	11.8 ft (3.5 m)	21.1 ft (6.6 m)	14.4 ft (4.3 m)
Av. Depth	8.6" (21.8 cm)	10.2" (25.9 cm)	6.8" (17.3 cm)
Gradient	6.4%	4.1%	7.6%
Av. Elevation	5684 ft (1733 m)	5658 ft (1725 m)	5675 ft (1730 m)
Dominant Substrates	Sands and Cobble	Cobble and Sands	Boulder and Gravel
Development	Logged	Logged	Pristine

METHODS AND MATERIALS

Field Study

Station Descriptions.

Six sampling sites were established for intensive study on the tributary streams, Trail, Dollar and Blackmare Creeks (Fig. 1). Sites were chosen on the basis of location, substrate characteristics and benthic sampling conditions. One site was selected in the lower reach of each tributary stream. Sites were established in riffles or riffle-run habitats, which are most productive and best indicators of insect life. Each sampling site ranged from 30 to 90 ft (9.1 to 27.3 m) long by 20 to 33 ft (6.0 to 9.9 m) wide.

In addition to the intensive sites, five "faunistic" stations were established on Dollar Creek extending from upper through lower reaches to give insight into the spatial distribution of benthic insects over an entire drainage (Fig. 1). The upper-most station was approximately 5 miles (8.0 km) from the South Fork confluence, the remaining stations were approximately 0.5 mi (0.8 km) apart. Substrate type at these stations was principally small and large cobble; water depths ranged from 5 to 12" (12.7 to 30.5 cm); stream width averaged 20 ft (6.0 m).

Station Quadrant Design.

Stations were divided into sampling quadrants in order to provide a more critical delineation of habitat types and permit more objective sampling of insects and substrate. Each station was divided transversely and longitudinally by string transect lines. Each quadrant

provided a well defined sampling area that could be consistently re-sampled on different dates. Benthic insect composition and substrate conditions were analyzed and compared on an intra and inter-quadrant basis as well as between stations and streams. Four quadrants were established on all intensive study stations except Station 1 where the stream size was too small.

Station and Stream Morphometrics.

Hydrology. The U. S. Forest maintains one primary hydrologic gauging station in the South Fork drainage near the Krassel Ranger Station, Idaho. The annual hydrographs from this gauging station provided the best information available for correlating discharge and run-off characteristics of the tributaries under investigations in this study. It is recognized, however, that the correlations are only approximate in that each drainage has its own peculiar characteristics of slope, exposure, vegetation and drainage area that contribute to inter-stream differences in flows.

Substrate Classification. Substrate-sediment conditions were evaluated visually along each transect line and bottom sample using a multiple-rank classification scheme modified from earlier studies by Prather (1971), McClelland (1972) and Sandine (1973). The parameters measured included cobble size, size of substrate surrounding cobble, cobble imbeddedness and stream profile. Substrate was ranked according to a 7-rank classification scheme (Table 2); a similar ranking was used to describe dominant sediment type surrounding cobble. If cobbles were not present with ranked values of four or greater at a point being sampled, then the dominant substrate type prevailed as the single

description. Cobble imbeddedness values were determined by the cobble's position relative to the sediment surrounding it. Cobble imbeddedness was described using a 5-rank classification scheme (Table 3). Imbeddedness values were not assigned to cobble having a rank of three or less; if a cobble rank was three or less, then dominant substrate values again prevailed as the single description.

Substrate-sediment conditions were also evaluated for each bottom sample to more definitively relate the microenvironment with the insects. Substrate-sediment conditions were correlated with benthic sample using simple regression equations (Snedecor and Cochran, 1972).

Transect Analysis. Transect lines traversing each stream site, were established to evaluate the stream profile over time. Substrate parameters discussed above (dominant substrate, substrate surrounding cobble and cobble imbeddedness) were taken at 1 ft (0.30 m) intervals along a string line extended between permanent stakes. Substrate profile data was correlated within and between stations using Duncan's Multiple Range test. Water velocities were measured at each transect line using a Gurley Pygmy Current Meter (Model No. 625, Teledyne Gurley Co., Troy, N. Y.) during each sampling period.

Core Sample Analysis. A core sampler designed by the U. S. Forest Service (McNeil et al., 1960) was used to obtain 12" (30.5 cm) sediment cores (Fig. 3). Substrate samples were taken from each station quadrant and screened using Tyler Standard Screens (W. S. Tyler Co., Mentor, Ohio) with mesh sizes of 0.742" (18.85 mm), 0.371" (9.39 mm), 0.185" (4.69 mm) and 0.093" (2.36 mm). Sediments were dried and weighed for substrate correlation analysis between study sites.

Table 2. Surface sediment classification of dominant substrate.

1.	Less than 1.5 mm in diameter (1/16") - fine sand and silt
2.	1.5 - 6.4 mm in diameter (1/16 - 1/4") - pea gravel
3.	6.4 - 25.4 mm in diameter (1/4 - 1") - small pebble
4.	25.4 - 63.5 mm in diameter (1 - 2 1/2") - large pebble
5.	63.5 - 127.0 mm in diameter (2 1/2 - 5") - small cobble
6.	127.0 - 254.0 mm in diameter (5 - 10") - large cobble
7.	Greater than 254.0 mm in diameter (10") - boulder

Table 3. Surface sediment classification of imbeddedness of cobble.

1.	Cobble unimbedded
2.	Cobble 1/4 imbedded
3.	Cobble 1/2 imbedded
4.	Cobble 3/4 imbedded
5.	Cobble fully imbedded

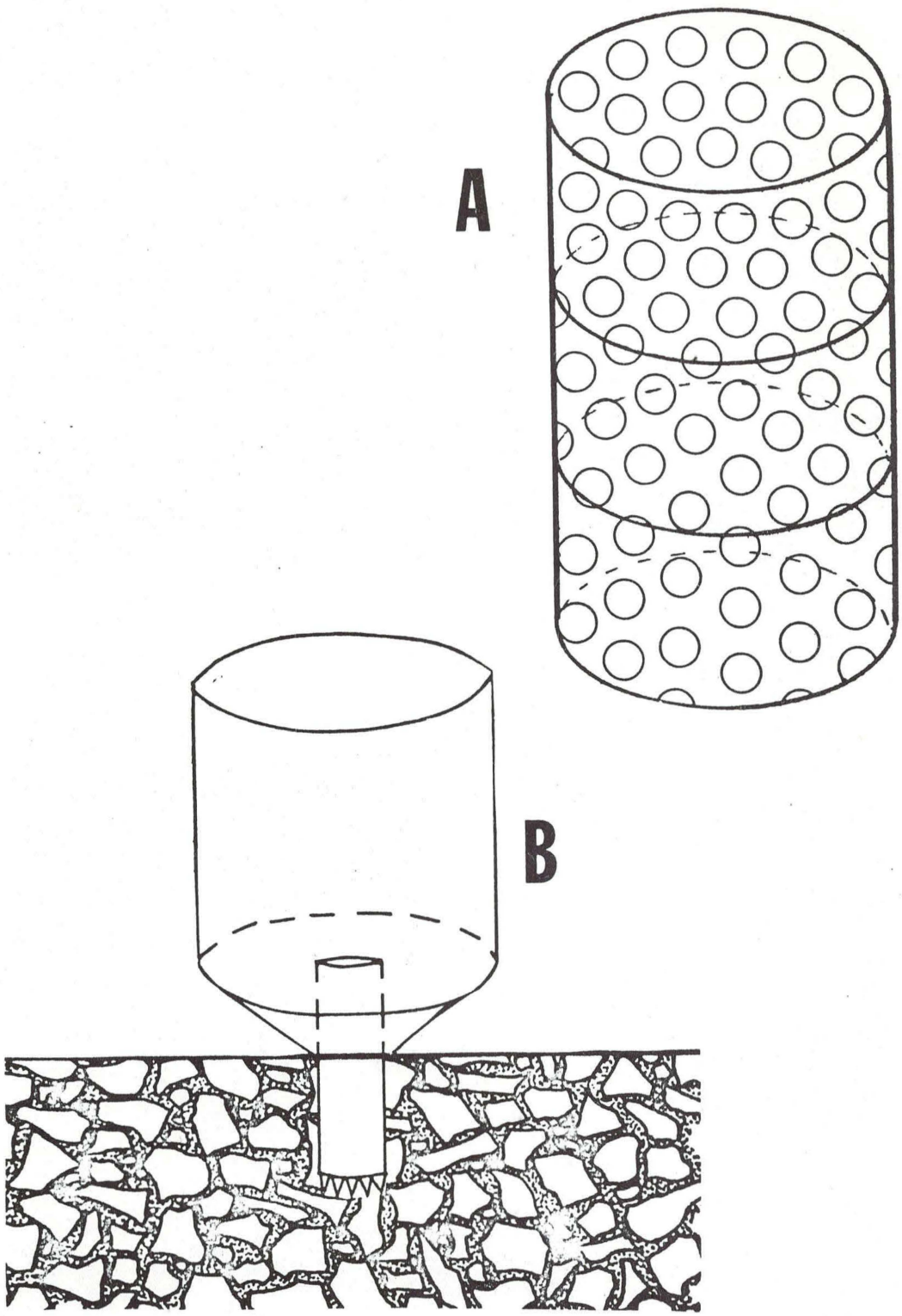

Fig. 3. Vertical sampling canister (A) and streambed core sampler shown inserted into streambed (B).

Benthic Sampling and Community Analysis.

Bottom Sample Technique. Benthos samples were selected randomly within each station quadrant. Three to four, 1 ft^2 (0.09 m^2) samples were taken per quadrant during July and September of 1972-74 using a bottom sampler similar to that described by Waters and Knapp (1961). The number of samples taken was adjusted to the size of the quadrant. Samples were obtained by stirring the substrate with a small metal hand-rake, then hand-wiping individual cobble to remove attached insects. The substrate within the perimeter of the bottom sampler was evaluated using the rank-classification analysis previously discussed (Tables 2,3). Substrates of large cobble and boulder were not sampled. Benthos samples were collected and preserved in 70% ethyl alcohol and identified to species when possible [Usinger (1968), Jensen (1966), Peterson (1962), Ross (1959), Ward and Whipple (1963), Pennak (1953) and Smith (1968)]. Questionable specimens were compared with determined specimens in the research collection, Department of Entomology, University of Idaho. Nymphs and larvae were classified into three age-classes on the basis of wing development and/or size. Each benthos sample was subsequently correlated with its associated substrate parameters.

Basket Sampling Technique. Basket samplers, constructed of 1/4" (0.64 cm) 6" x 12" x 12" (15.2 x 30.5 x 30.5 cm) hardware cloth, were used to supplement conventional bottom samples. The baskets were filled with 20 fist-sized cobbles (63.5 - 127.0 mm) and completely submersed in the test riffles. Single baskets were placed at intensive study sites as well as the five "faunistic" stations on Dollar Creek. Basket samples were used only for Dollar Creek sites (including "faunistic" stations) in 1972, but were used to sample all intensive study sites in

1973 and 1974. Baskets were placed in the stream during early July and removed in early September, thus allowing a two-month colonization period. Insects were collected from the baskets by inserting the entire basket into a 30 gallon (114 liter) plastic container partially filled with water. The rocks and basket were hand rubbed and rinsed to remove insects. The contents were subsequently strained through a fine mesh net, then transferred to a museum jar partially filled with 70% ethyl alcohol for later sorting and identification. Species composition and diversity analyses were performed on all basket samples.

Canister Sampling Technique. Metal sampling canisters [5.5" (13.47 cm) x 12" (30.48 cm)] were designed to evaluate vertical migration patterns of benthic invertebrates and test the hypothesis that insects move into the substrate as a means of escaping sediment scour and high flow conditions (Fig. 3). The canisters were constructed of #16 gauge, perforated sheet metal with 1/2" (1.27 cm) holes; the perforations allowed approximately 45% "flow through" penetration. Surface sampling area was approximately 1/6 sq. ft (0.006 m^2) sampling volume approximately 1/6 cu ft (0.306 m^3). Each canister was divided into three, 4" (9.16 cm) sampling levels by removable, perforated circular plates. The canister bottom was of non-perforated #16 gauge black metal. A removable "bail" handle inserted into eyelets at the rim of the canister facilitated easy insertion and removal of the canister.

In preparation for canister insertion into the streambed, pebble (1.5 - 6.35 mm) was placed in each level of the sampling canister. A sediment core sampler (Fig 3) was inserted into the streambed and the sediments removed. The canister was inserted and core sampler removed

leaving the canister imbedded flush with the surface sediments. The canister was removed by again placing the core sampler over the canister and removing the latter, thus preventing escapement of benthos via horizontal shifting. The insects were separated from the sediments, sorted and identified. The sediments were dry sieved and analyzed into size classes.

Sampling canisters were installed at each of the six intensive sampling sites on the three tributary streams. Samples were taken over a series of five consecutive sampling periods: Spring (June 27, 1973-July 18, 1973; 23 day test); Summer (July 18, 1973 - September 5, 1973; 49 day test); Winter (September 5, 1973 - May 5, 1974; 240 day test); Early Spring (May 5, 1974 - July 8, 1974; 64 day test); and Summer (July 8, 1974 - September 10, 1974; 64 day test). Species diversity analyses were performed on all canister samples. Chironomids were not included in the canister analysis because the taxonomy of this group has not been resolved.

Drift Sampling Technique. Insect drift samples were taken annually (1972 - 1974) on lower Trail Creek (Station 2), and lower Blackmare Creek (Station 6). Drift was used as another means of estimating production and evaluating in-stream colonization. Drift samples were taken using two, 1 ft^2 (30.48 cm x 30.48 cm) drift nets with nylon netting having 0.8 mm pore size. The two nets were equally spaced across the streambed to provide a dual evaluation of drift patterns in a stream and between streams. Samples were taken at 4-hour intervals over a 24-hour period during mid-August of each sampling year. Samples were preserved in 70% ethyl alcohol for later sorting and analysis.

Community Similarity and Cluster Analysis. Insect communities were analyzed using Patten's (1962) equations for species diversity. Values obtained included diversity per individual and redundancy. Diversity values indicate the degree of heterogenity of the insect community. Values less than one indicate heavily polluted conditions while values of approximately three indicate an unpolluted, diversely productive condition (Wilhm, 1972).

A community similarity matrix based on a pair-wise comparison for benthic community composition was generated using a program modified from Davies (1971). Data for the program was in binary notation using 1 for presence and 0 for absence of a species. A Jaccard coefficient was computed for each community comparison. Value of 0.0 indicate no similarity (no common species); 1.0 indicates identity (all species present in both communities). Similarity matrices and cluster analyses were generated for 1972, 1973 and 1974 benthos data from all intensive study stations.

Laboratory Study

Insect-Substrate Colonization.

Laboratory investigations were conducted to determine drift and colonization rates under unsedimented, moderate and heavily sedimented conditions in an artificial plexiglas channel. The channel was 18 ft long (4.49 m) and consisted of two sections, eight and ten ft (2.44 and 3.05 m) long and 10" (25.4 cm) wide, connected by a flexible rubber joint to permit varying slope adjustments. The channel was constructed of 1/4" (0.64 cm) plexiglas walls and a 3/4" (1.91 cm) plywood base. The channel was divided into seven, 2 ft (61 cm) quadrants to facilitate recording insect distribution patterns. A net was positioned at the out flow of the channel to collect test specimens drifting out of the system. A small hydraulic jack was used to adjust the channel gradient. A 3/4 h.p. centrifical pump (Bell and Gossett, Series 1522-45, maximum discharge 100 gal/minute) was used to circulate water through the system. Water temperature was maintained at approximately 10° C with a 3/4 h.p. refrigeration unit. Stream velocity was maintained at approximately 1 ft/sec (0.30 m/sec). Sediments used in the channel were obtained from the field and screened to desired size.

Two stoneflies, Pteronarcella sp. and Acroneuria sp., and a mayfly, Ephemerella grandis Eaton, were used as test specimens. Specimens were pre-conditioned in a circular laboratory stream described by Brusven (1973). Tests were performed using large pebble in an unsedimented and moderately sedimented condition. Sand was deposited around the pebble to effect moderate sedimentation (1/2 - 3/4 imbedded). Each test was

replicated three times using 20 insects per test. The insects were introduced into the water column in the middle reach of the stream. Each test lasted 24 hours; at the end of the test the insects were recovered and recorded from each 2-foot quadrant and out-flow net. Twelve hour, light-dark conditions were maintained with an automatic florescent light and timer. Current velocity of 1.0 ft/sec (0.3 m/sec) was maintained for all replications.

Insect Vertical Distribution.

An artificial linear channel [8 ft (2.4 m) x 10" (25.4 cm) x 14" (25.5 cm) high, constructed of 3/4" (1.9 cm) plywood] was used to determine the effect of sediment on vertical distribution of aquatic insects. The channel was designed to accomodate the vertical sampling canister described earlier (Fig. 3).

Insects were confined to the test section of the channel with 1/16" (0.16 cm) mesh aluminum screen. The test section was approximately 28" (61.1 cm) in length and represented a closed system preventing the insects from migrating out of the retained substrate. Large pebble (25.4 - 63.5 mm) and sand (less than 1.5 mm), deposited to a depth of 12" (30.4 cm), were used as test substrates.

Three sediment-filled canisters were inserted into the test section of the channel. Tests were conducted with three substrate types (large pebble, small pebble and gravel), each replicated three times. Small pebble and sand surrounding the canisters were used in various combinations with the sediments within the canisters.

A centrifical pump (Bell and Gossett, op cit) was used for circulating the water. Flow through the system with canisters implanted,

averaged 30 gal/min (113.7 liters/minute). Percolation rate averaged 6 gal/min (22.7 liters minute) or a 20% "flow-through" penetration. Water temperature was maintained at approximately 10° C. Surface stream velocity was approximately 1.0 ft/sec.

Four insect species, Pteronarcella sp., Acroneuria sp., Rhyacophila acrepedes Banks and Emphemerella flavilinea McDunnough were used in the experiment. A minimum of 30 test insects were released into the test reach and allowed to remain in the closed system for 24 hours. Percent recovered from each level was recorded. Twelve-hour, light-dark conditions were maintained with an automatic timer and florescent light. At the end of a test, canisters were removed by first sliding a sheet metal "sleeve" around each canister, thus preventing the loss of insects. The insects were then recovered and vertical distribution patterns recorded for each canister.

RESULTS

Field Study

Physical Stream Characteristics.

Flow. Flow records for 1967-1974 (U.S. Department of the Interior flow records, 1974) on the South Fork Salmon River near the Krassel Ranger station show a mean monthly discharge of 637 cfs for a drainage area of 850 square kilometers (Table 4). Peak flows occur during May and June and July. An abnormally high flow was recorded for 1974 and an abnormally low flow in 1973 (Fig. 4; Table 4). Annual flows have been above normal (567 cfs) since 1969 except for the low water year of 1973 (Fig. 5). The record high flood in 1974 has been estimated as being in excess of a 100-year flood event (Personal communication; Norbert Kulesza).

Gauging stations were not located on Trail, Dollar and Blackmare Creeks so continuous flow records for these streams were not available. Gauging station records of the South Fork Salmon River near Krassel Ranger Station, Idaho were used to evaluate seasonal flow cycles since it provided the best information available.

Flows were calculated (1972-74) for each study site at the time of insect sampling (Table 5). Lowest flows occurred in 1973 and highest flows in 1974. Mid-summer flows for Blackmare Creek more closely correlated with flows in the South Fork Salmon River than other tributaries studied (Table 5; Fig. 8).

Substrate. The forces of velocity and water volume affected the streambed to varying degrees over the three-year sampling period.

Table 4. Mean monthly and annual discharge (cfs) near Krassel Ranger Station on South Fork of the Salmon River, Idaho. Drainage area, 330 square miles (850 sq. kilometers); altitude of the gage, 3,750 feet (1143 meters). (Flow records from U.S. Geological Survey, Waters Resources Division, U.S. Dept. of the Interior).

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Water Yr Average
1966-67	111	139	148	171	149	180	277	1692	2558	742	181	126	540
1967-68	206	197	167	134	267	310	427	1268	1481	338	186	154	427
1968-69	181	262	196	301	212	227	1076	2550	1620	394	157	127	610
1969-70	147	129	127	266	215	230	318	1780	2699	754	211	216	591
1970-71	177	335	317	377	309	268	709	2783	3082	1065	272	168	823
1971-72	149	148	152	146	190	481	510	1919	2979	607	206	152	636
1972-73	152	145	251	301	137	155	309	1232	915	259	122	130	344
1973-74	137	529	429	779	348	627	1067	2067	3645	2846	792	247	1126
Average	158	236	223	308	228	310	587	911	2372	876	266	165	637

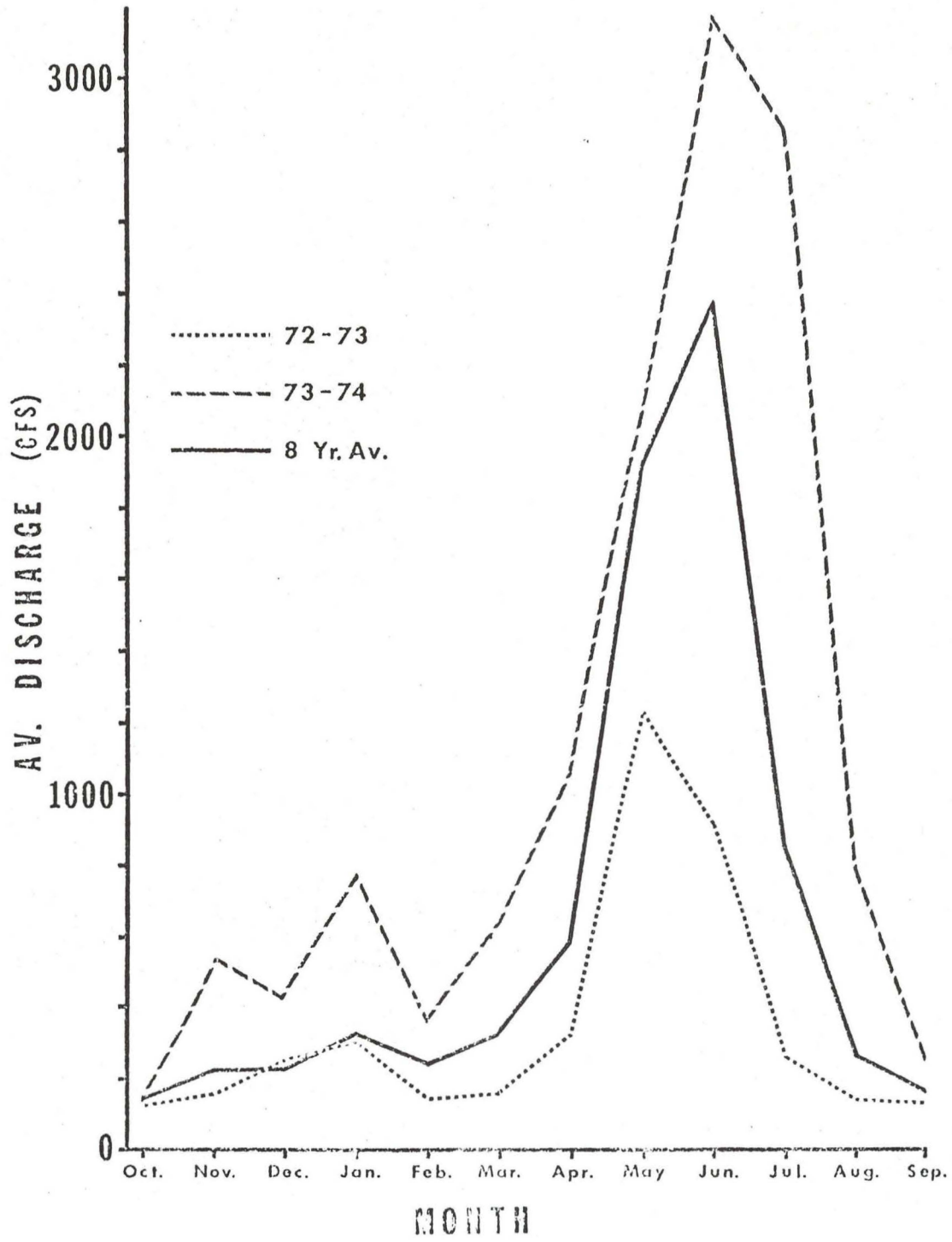

Fig. 4. Monthly water year averages (cfs) for 1972-73, 1973-74 and eight year average near the Krassel Ranger Station on the South Fork Salmon River, Idaho. Water year = October 1 to September 30. (Data from U.S. Geological Survey, Water Resources Division, U.S. Department of the Interior).

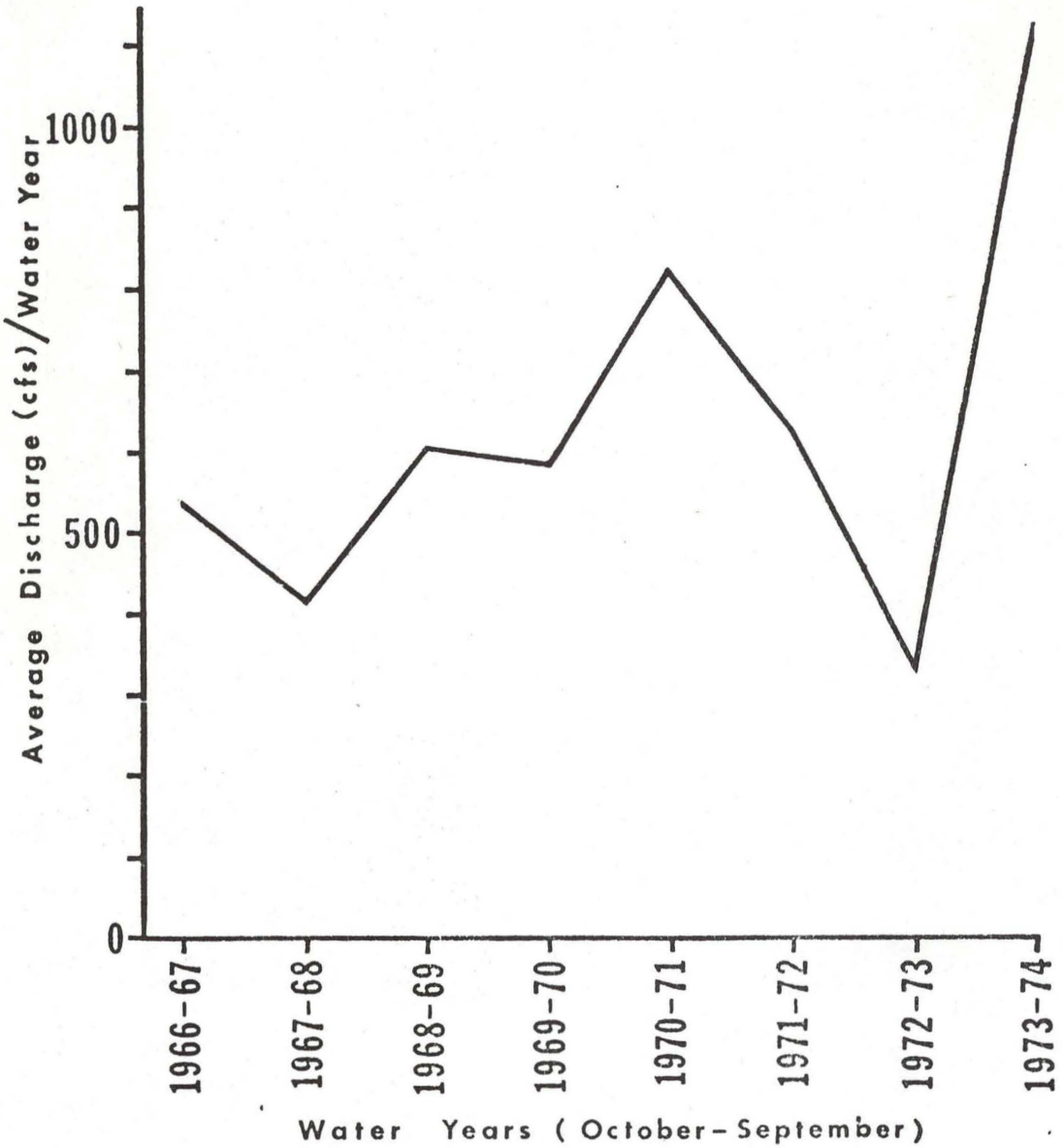

Fig. 5. Average discharge (cfs) per water year from 1966 to 1974 for the South Fork Salmon River near Krassel Ranger Station, Idaho. Water year = October 1 to September 30. (Data from U.S. Geological Survey, Water Resources Division, U.S. Department of the Interior).

Greatest substrate changes occurred during the 1973-74 high flows (Figs. 6-8).

Late August transect values were used to generate streambed cross-sections for each station. Generally, streambed profiles indicated a deepening and scouring of the streambed each year monitored.

Upper Trail Creek (Station 1) experienced minor substrate scour over the sampling period (Fig. 6). A log lodged in the streambed during 1972-73 was removed by the 1974 high flow and caused some streambed change. Lower Trail Creek (Station 2) scoured during the 1973 spring run-off, followed by moderate deposition of sands during 1974.

The profiles of upper and lower Dollar Creek (Stations 3 and 4) reflected moderate yearly changes (Fig 7). Several cobble shifted position in upper Dollar Creek during 1973 causing high points along the streambed profile. Lower Dollar Creek had noticeable deposition of sands and gravel in 1972, but became channelized in 1973 and 1974. Channel depth and width increased for both stations during the study while stream substrate type remained relatively unchanged (Fig. 7; Table 6).

The profiles of upper and lower Blackmare Creek (Stations 5 and 6) showed greater changes than Trail and Dollar Creek during the three-year period (Fig. 8). The mid-summer discharge for Blackmare Creek was approximately twice that of the other test streams; average current velocities were also greater for this stream (Table 5). The substrate at station 5 was largely cobble and boulder (Table 5). The streambed was not appreciably channelized after the 1974 flood (Fig. 8). At station six, the middle of the stream became channelized in 1974 with deposition of sediments near shore.

Table 5. Station Morphometrics and flow for late summer 1972, 1973 and 1974 for Trail, Dollar and Blackmare Creeks.

Creek	Station	Year	Av. Depth		Av. Width		Av. Velocity		Discharge		Dominant Substrate
			in.	cm.	ft.	m	ft/sec	m/sec	ft^3/sec	m^3/sec	
Upper Trail	1	1972	4.4	11.2	20	6.1	1.56	0.47	8.98	0.25	Lg. Cobble-
		1973	3.1	7.8	20	6.1	1.60	0.48	6.65	0.18	Boulder
		1974	4.2	10.6	20	6.1	1.44	0.43	7.83	0.22	
Lower Trail	2	1972	6.3	15.9	29	8.8	1.20	0.36	14.47	0.40	Small Cobble
		1973	6.4	16.2	20	6.1	1.25	0.38	10.60	0.30	
		1974	6.7	17.0	27	8.2	1.24	0.37	14.43	0.40	
Upper Dollar	3	1972	7.5	19.0	19	5.8	1.57	0.47	14.79	0.40	Large Cobble
		1973	6.8	17.2	19	5.8	1.45	0.44	12.34	0.34	
		1974	8.7	22.0	19	5.8	2.03	0.61	22.21	0.62	
Lower Dollar	4	1972	6.8	17.2	11	3.3	1.58	0.48	7.92	0.22	Small Cobble
		1973	5.1	12.9	14	4.3	2.25	0.68	10.58	0.29	
		1974	8.2	20.8	15	4.5	1.20	0.36	9.79	0.27	
Upper Blackmare	5	1972	8.5	21.5	28	8.5	1.39	0.42	21.79	0.61	Lg. Cobble-
		1973	7.8	19.7	28	8.5	1.93	0.58	28.10	0.79	Boulder
		1974	8.3	21.0	28	8.5	2.20	0.67	34.00	0.96	
Lower Blackmare	6	1972	5.1	12.9	32	9.7	1.61	0.49	17.31	0.49	Small Cobble
		1973	4.9	12.4	32	9.7	1.61	0.49	16.89	0.47	
		1974	7.4	18.7	27	8.2	2.30	0.70	30.30	0.85	

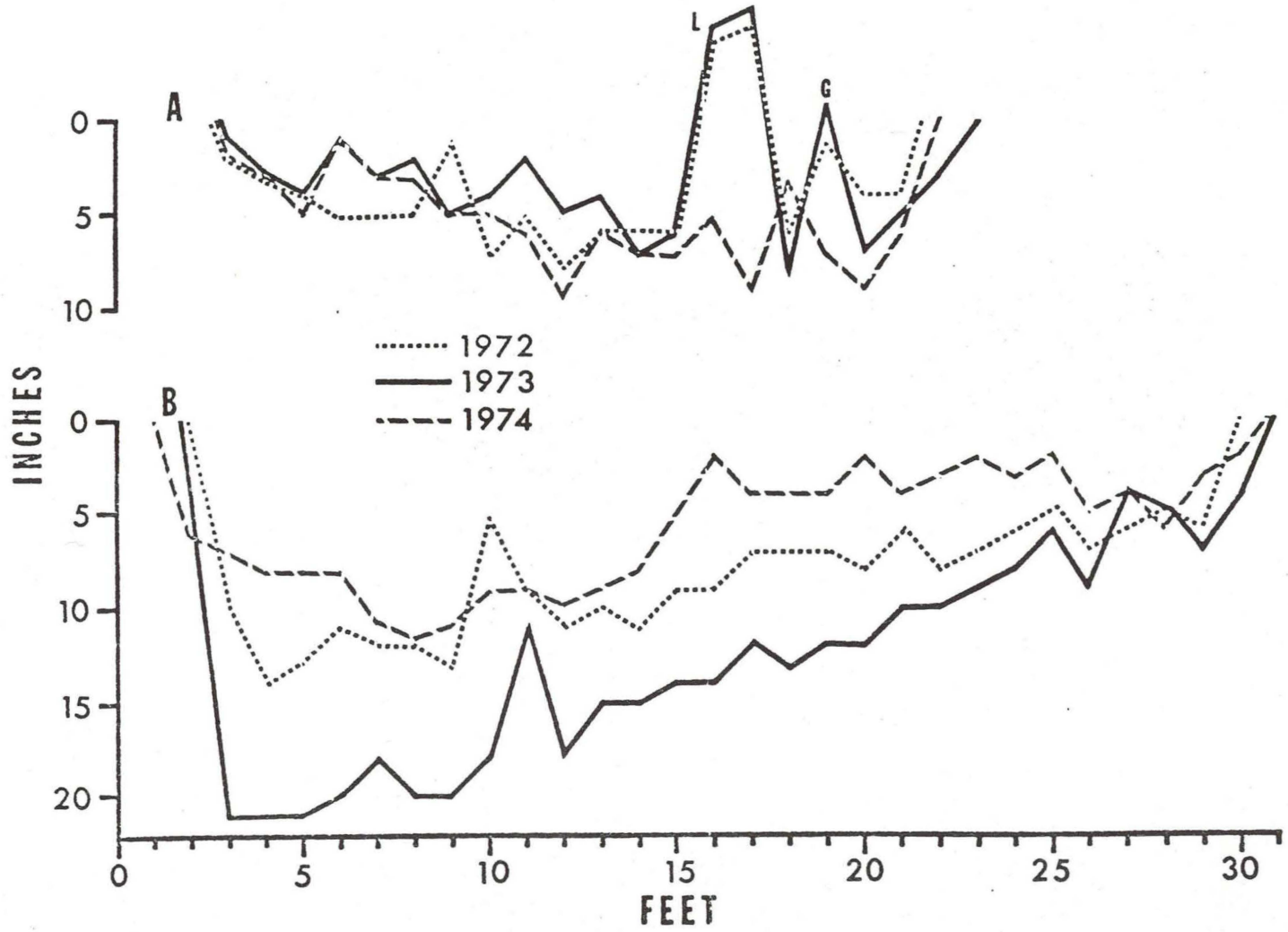

Fig. 6. Stream profiles for (A) upper Trail Creek (Station 1) and (B) lower Trail Creek (Station 2) for 1972, 1973 and 1974. L = log and G = ground.

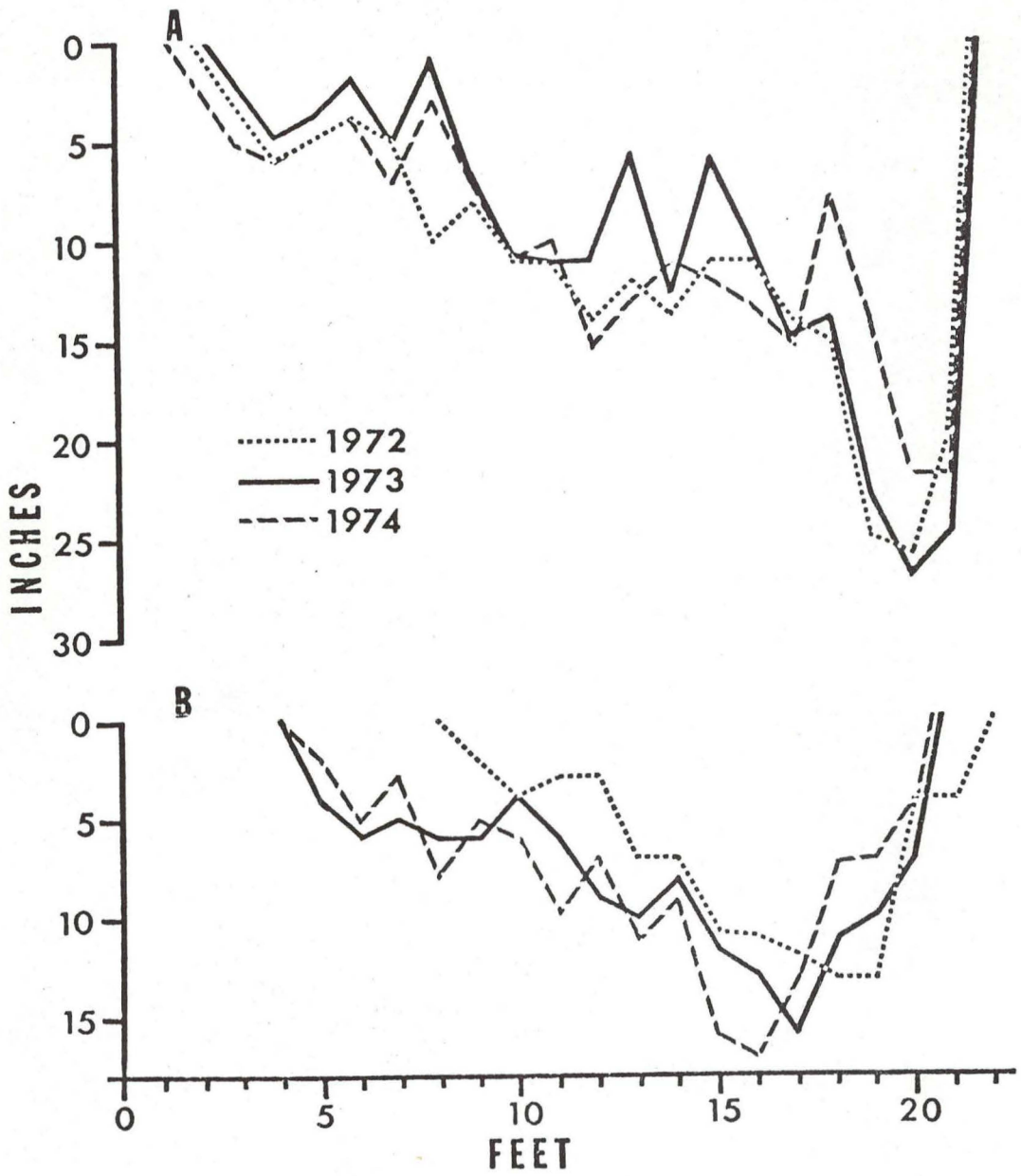

Fig. 7. Stream profile for (A) upper Dollar Creek (Station 3) and (B) lower Dollar Creek (Station 4) for 1972, 1973 and 1974.

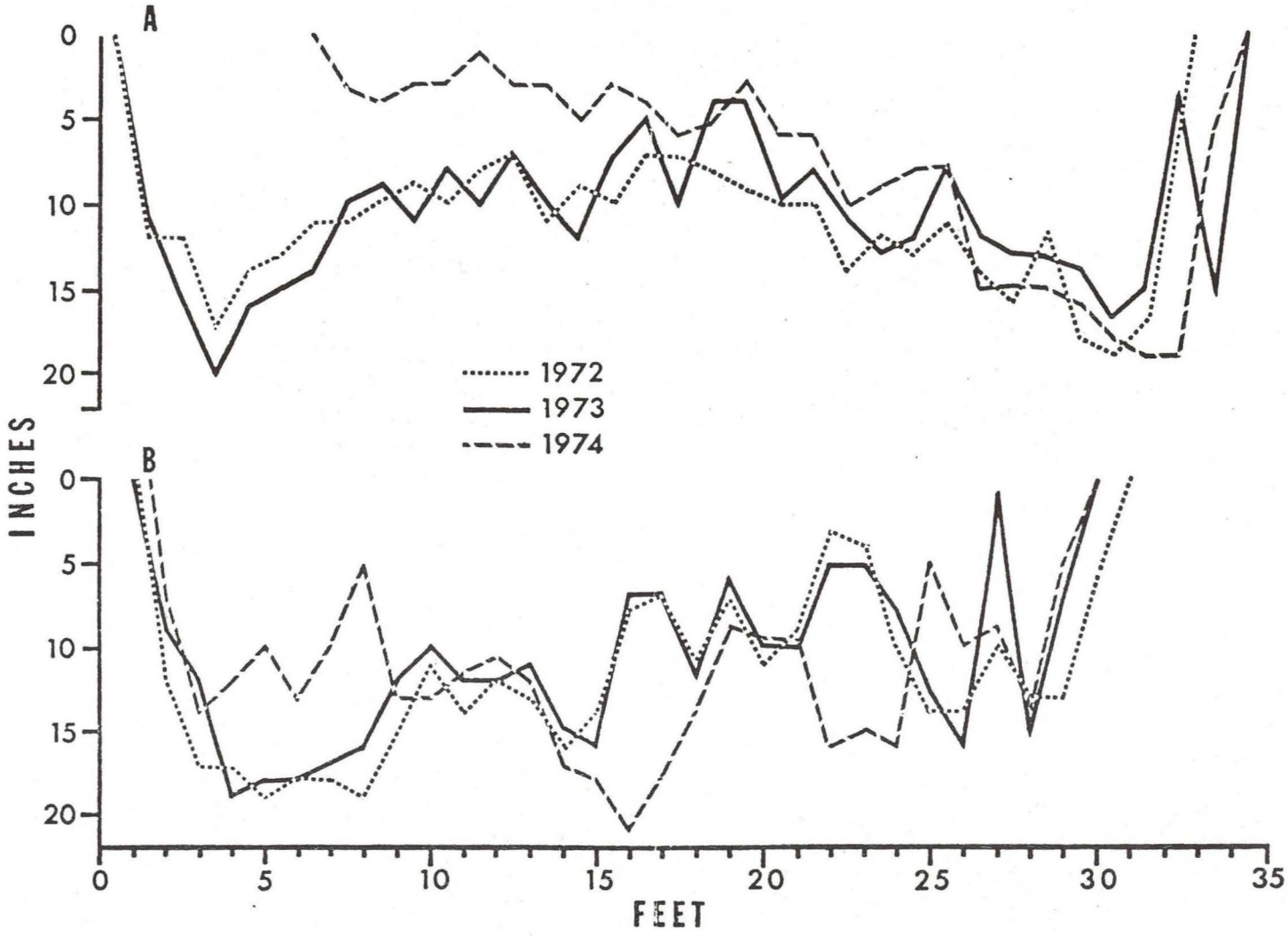

Fig. 8. Stream profile for (A) upper Blackmare Creek (Station 5) and (B) lower Blackmare Creek (Station 6) for 1972, 1973 and 1974.

The Duncan's Multiple Range test was used to statistically evaluate similarities and dissimilarities of changing substrate rank within and between stations (Table 6). Substrate ranks obtained along transect lines included cobble size, imbeddedness of cobble and sediment surrounding cobble.

Cobble size, imbeddedness of cobble and sediment surrounding cobble remained relatively similar (5% range) for the upper stations (1,3,5) of each test creek during the study (Table 6). The upper stations of each creek were dominated by large cobble and/or boulder. The dominant substrate ranks for stations two (Trail Creek) and six (Blackmare Creek) were statistically similar for 1972 and 1973. The ranked values in 1974 indicated a reduction in sediment size.

The dominant substrate in lower Dollar Creek (Station 4) was statistically similar in 1972 and 1973. The ranked means increased in 1974, suggesting an increase in dominance of large pebble (Table 6).

Little change was noticed in rank means of substrate surrounding cobble among the three streams in 1972-74 (Table 6). Small changes occurred in upper Trail and upper and lower Dollar Creeks. These changes were not large enough, however, to suggest a character change in substrate, e.g. from sand to pebble or pebble to cobble between years.

Cobble imbeddedness values were evaluated by the degree of cobble imbeddedness within the streambed. Cobble, 75% exposed to the water column, was considered 1/4 imbedded, cobble 50% exposed was considered 1/2 imbedded, etc. Cobble imbeddedness values remained relatively unchanged (5% level) for stations on Trail and Dollar Creeks from 1972 through 1974, while noticeable variations occurred in Blackmare

Table 6. Substrate rank means and statistical comparisons for dominant substrate, surrounding material and imbeddedness (Duncan's Multiple Range Test) for intensive study stations for 1973-74. Stations with the same identification letters are statistically similar at the 5% level. Sediment rank classification is found in Table 2.

Creek	Station	Mean Dominant Substrate Rank			Statistical Sets		
		1972	1973	1974	1972	1973	1974
Upper Trail	1	3.77	3.41	4.13	AB	A	ABC
Lower Trail	2	4.64	4.07	3.67	CDE	ABC	A
Upper Dollar	3	5.22	5.22	5.24	DEF	EF	EF
Lower Dollar	4	4.23	3.60	4.47	ABC	A	BCD
Upper Blackmare	5	5.48	5.20	5.45	F	EF	F
Lower Blackmare	6	4.96	4.92	4.22	DEF	DEF	ABC

Creek	Station	Mean Surrounding Material Rank			Statistical Sets		
		1972	1973	1974	1972	1973	1974
Upper Trail	1	2.00	2.03	2.18	A	A	B
Lower Trail	2	2.15	2.04	2.01	B	A	A
Upper Dollar	3	2.01	2100	2.16	A	A	B
Lower Dollar	4	1.98	2.00	2.18	A	A	B
Upper Blackmare	5	2.01	2.00	2.05	A	A	A
Lower Blackmare	6	2.05	2.00	1.98	A	A	A

Creek	Station	Mean Imbeddedness Rank			Statistical Sets		
		1972	1973	1974	1972	1973	1974
Upper Trail	1	2.17	2.00	1.86	ABCD	ABC	ABE
Lower Trail	2	1.92	1.95	1.88	AB	AB	ABE
Upper Dollar	3	2.01	2.34	2.03	ABC	CD	ABC
Lower Dollar	4	2.03	2.20	2.12	ABC	ACD	ABC
Upper Blackmare	5	1.94	2.25	1.67	AB	CD	E
Lower Blackmare	6	2.08	2.40	2.05	ABC	D	ABC

Creek for this substrate condition (Table 6). The average cobble imbeddedness value for all stations was approximately 1/4 imbedded.

Average sediment core samples for all sites indicated over 40% of the sediments were pebble size or smaller, i.e. finer than 0.742" (18.85 mm) (Table 7). Over 30% of the sediments were gravel and sand and approximately 27% coarse and fine sand and silt, i.e. finer than 0.371" (9.39 mm) and 0.185" (4.69 mm), respectively. Most streams and stations had less than 5% variation for any given particle size catagory thus, indicating tributary substrate composition was relatively similar.

Sediment core samples for station quadrants showed sediment size-class variations. Lower Trail Creek (Station 2), for example, had 37-50% of the sediments finer than 18.85 mm; other sediment size classes demonstrated similar variability. Inter-stream comparison of intensive study sites showed less than 5% variability in sediment composition.

Table 7. Sediment core analysis of percent finer material for quadrants (A,B,C,D) and station averages for Trail, Dollar and Blackmare Creeks, 1972.

Creek	Station	Size Class	% Finer/Quadrant A	B	C	D	Av.
Trail	1	0.742" (18.85 mm)	51.65	44.50	*	*	48.08
		0.371" (9.39 mm)	42.05	37.45	*	*	39.75
		0.185" (4.69 mm)	32.00	28.25	*	*	30.12
		0.093" (2.36 mm)	19.05	17.90	*	*	18.47
Trail	2	0.742" (18.85 mm)	50.50	57.30	49.55	37.30	48.66
		0.371" (9.39 mm)	39.37	50.25	35.55	27.95	30.28
		0.185" (4.69 mm)	30.16	42.65	25.60	19.05	29.36
		0.093" (2.36 mm)	19.43	31.00	15.05	10.30	18.94
Dollar	3	0.742" (18.85 mm)	52.45	34.00	49.70	39.20	43.83
		0.371" (9.39 mm)	39.95	25.65	40.35	31.50	34.36
		0.185" (4.69 mm)	25.50	17.95	31.10	22.80	24.33
		0.093" (2.36 mm)	11.20	9.55	10.75	11.70	12.80
Dollar	4	0.742" (18.85 mm)	42.35	43.50	64.65	45.15	48.91
		0.371" (9.39 mm)	30.64	34.65	56.00	39.00	40.07
		0.185" (4.69 mm)	21.00	25.35	42.45	30.00	29.70
		0.093" (2.36 mm)	12.78	14.70	21.00	10.80	16.82
Blackmare	5	0.742" (18.85 mm)	50.20	44.20	38.50	42.20	43.77
		0.371" (9.39 mm)	40.80	35.00	21.00	31.90	23.17
		0.185" (4.69 mm)	32.00	25.10	13.60	23.00	23.42
		0.093" (2.36 mm)	20.00	14.80	7.40	13.30	13.87
Blackmare	6	0.742" (18.85 mm)	40.50	25.65	40.95	67.45	43.88
		0.371" (9.39 mm)	30.25	40.15	31.05	60.85	33.01
		0.185" (4.69 mm)	21.70	31.65	22.90	51.30	31.88
		0.093" (2.36 mm)	12.14	22.15	13.60	39.20	21.77

* No Samples taken.

Benthic Community Analysis.

Intensive Study Sites. Seventy-nine species representing 60 genera and five orders of insects were found in the three tributary streams of the South Fork Salmon River (Appendicies A-C). Density and number of species for nearly all stations was greater in 1973 than in 1972 or 1974. Blackmare Creek, however, showed a steady increase in density during the study (Table 8). Mayflies dominated the benthic community in all tributary streams during the study.

Diversity for each tributary stream decreased over the sample period. Density, however, increased from 1972 to 1973 then decreased in the summer of 1974 (Table 8; Figs. 9,10). Species as Dicranota sp., Neophylax sp., Epeorus grandis (McDun.), Brachyptera sp., Ameletus sp. and Ephemerella doddsi Needham continued to decrease in total numbers in the summer of 1974 (Appendicies A-C). The increase in diversity and density for the fall of 1973 probably resulted from samples being taken approximately two weeks earlier (due to early winter) than fall samples in 1972 and 1973 (Table 8; Figs. 9,10). Redundancy values remained relatively similar for all sampling periods except the summer of 1974 when they were higher (Table 8).

The insect communities in upper and lower Trail Creek (Stations 1 and 2) reflected summer-fall community fluctuations. Highest diversity and density was generally recorded during the fall sampling period. Ephemeroptera was the dominate order; Trichoptera ranked second in percent numbers and species (Figs. 11,15). The most common summer species were the mayflies, Baetis bicaudatus Dodds and Cinygmula sp.; abundant fall species included Ephemerella spinifera Needham and Ephemerella doddsi Needham (Appendix A). The highest diversity value

Table 8. Diversity, redundancy, density (No./m^2) and number of species for six intensive study stations for summer and fall, 1972-1974.

Stations	Diversity		Redundancy		No. Spp.		Density	
	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall
Upper Trail Cr. (1)								
1972	3.49	4.05	0.23	0.20	26	36	156.0	758.5
1973	2.94	3.42	0.27	0.14	31	36	411.5	653.6
1974	2.52	3.46	0.38	0.14	25	38	333.5	496.3
Lower Trail Cr. (2)								
1972	3.59	3.57	0.22	0.24	36	37	199.7	383.9
1973	2.89	3.37	0.25	0.26	42	47	322.8	786.8
1974	3.03	2.98	0.21	0.16	33	31	347.6	211.8
Trail Cr. (Av.)								
1972	3.54	3.81	0.22	0.22	46	43	185.0	508.8
1973	2.91	3.39	0.26	0.20	49	51	352.4	742.4
1974	2.77	3.22	0.29	0.15	36	44	342.9	306.6
Upper Dollar Cr. (3)								
1972	3.14	3.66	0.17	0.15	26	34	157.8	446.5
1973	3.03	3.57	0.27	0.20	41	54	400.0	968.0
1974	2.80	3.31	0.28	0.13	39	42	320.1	357.7
Lower Dollar Cr. (4)								
1972	3.58	3.36	0.19	0.22	34	39	158.0	420.3
1973	2.96	3.76	0.27	0.19	35	52	380.6	1017.4
1974	2.78	3.27	0.25	0.12	29	36	272.3	314.7
Dollar Cr. (Av.)								
1972	3.36	3.64	0.18	0.18	37	42	157.9	431.5
1973	2.99	3.66	0.27	0.20	41	54	400.0	968.0
1974	2.80	3.31	0.28	0.13	39	42	320.1	357.7

Table 8. (continued).

Station	Diversity		Redundancy		No. Spp.		Density	
	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall
Upper Blackmare Cr. (5)								
1972	2.96	3.48	0.30	0.23	28	36	277.0	661.7
1973	2.83	3.48	0.32	0.20	30	42	477.0	684.1
1974	2.12	3.28	0.44	0.21	31	38	616.0	568.4
Lower Blackmare Cr. (6)								
1972	3.30	3.73	0.27	0.17	31	31	286.0	589.1
1973	2.96	3.55	0.28	0.21	35	39	602.5	727.1
1974	2.74	3.36	0.37	0.25	31	37	705.6	753.2
Blackmare Cr. (Av.)								
1972	3.13	3.60	0.28	0.20	36	40	280.8	625.4
1973	2.89	3.51	0.30	0.20	41	46	539.7	705.6
1974	2.43	3.32	0.40	0.23	37	40	660.8	660.8

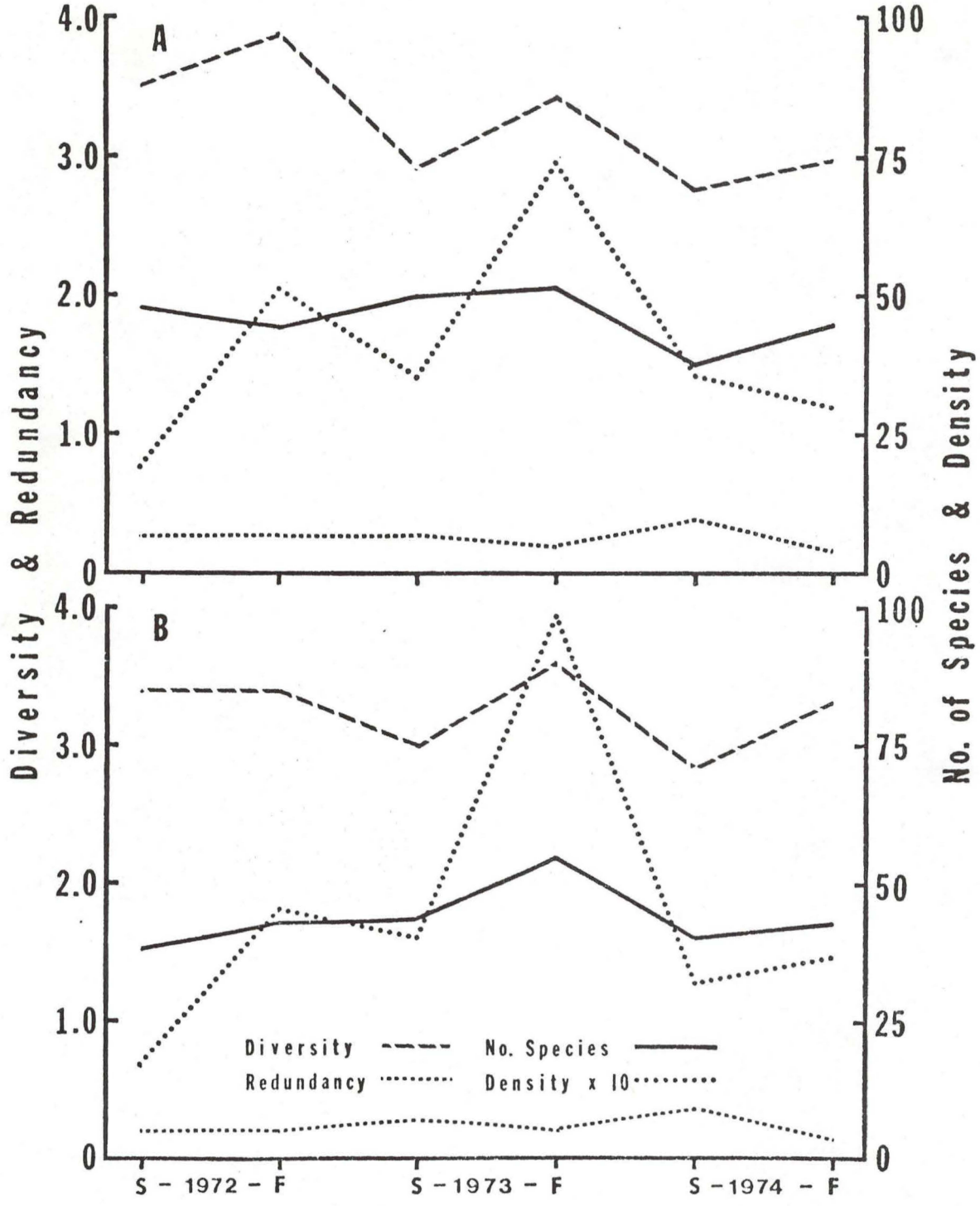

Fig. 9. Diversity, redundancy, number of species and density for (A) Trail and (B) Dollar Creeks, 1972-1974.

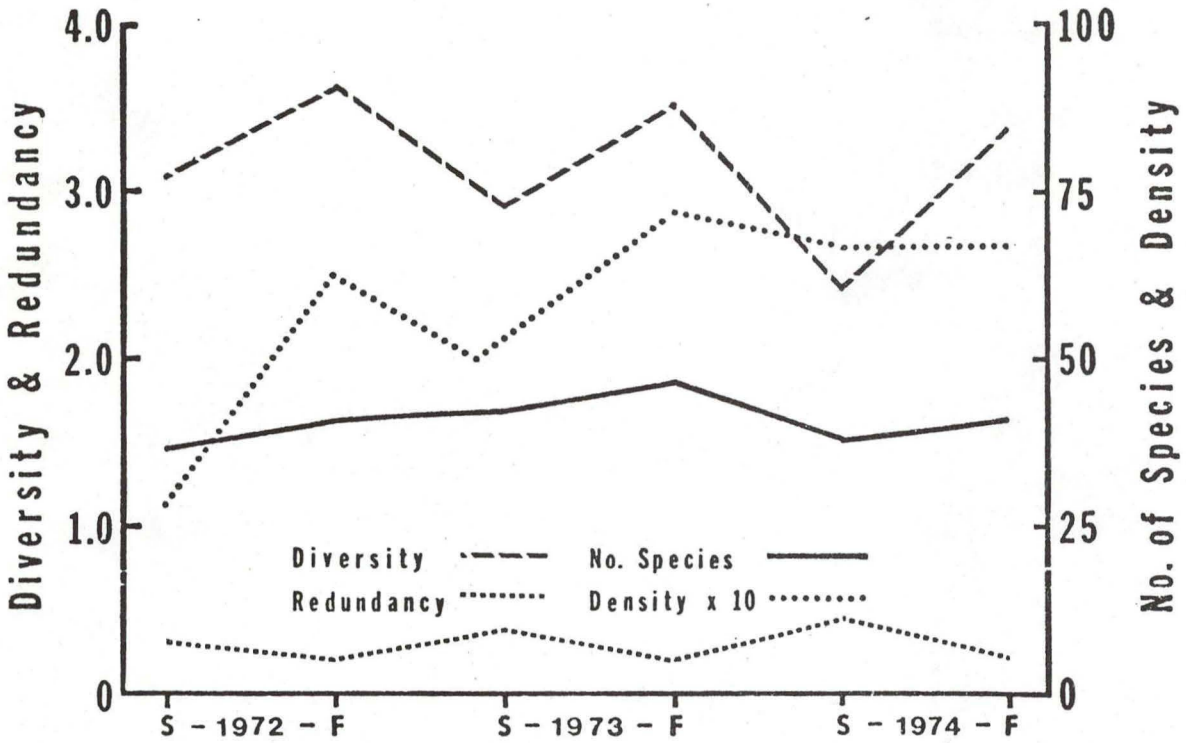

Fig. 10. Diversity, redundancy, number of species and density for Blackmare Creek, 1972-1974.

during the study was 4.05, recorded during the fall of 1972 in Trail Creek (Table 8). The three-year diversity average for Trail Creek was over 3.0.

Lower Trail Creek (Station 2) generally supported more species than upper Trail Creek (Station 1). Brachyptera sp., Arctopsyche grandis (Banks, Brachycentrus sp., Dicosmoecus sp. and Tipula sp. were present only in Station 2. In the fall of 1974, fewer species were collected in lower Trail than upper Trail Creek (Figs. 11,15). Paraleptophlebia heteronea (McDun.), Rhithrogena hageni Eaton and Ephemerella edmundsi Allen experienced a reduction at Station 2 in the fall, 1974. Summer densities were similar for both stations during the study, while fall densities were much higher for Station 1 in 1972 and 1974.

Upper Trail Creek experienced greater changes in density during the summer-fall sampling periods than lower Trail Creek (Figs. 11,14,15; Table 8). The mayflies, R. hageni Eaton and Baetis bicaudatus Dodds, contributed the largest fluctuations in upper Trail Creek, chironomids in lower Trail Creek. The number of species and density for Plecoptera, Trichoptera and Coleoptera remained relatively unchanged during the study. Community redundancy values remained similar for both Trail Creek sites during the study (Fig. 11; Table 8).

Dollar Creek (Stations 3 and 4) reflected seasonal density fluctuations similar to Blackmare and Trail Creeks (Fig. 12,14,15). Common mayflies included R. hageni, B. bicaudatus, Epeorus albertae (McDun.) and Cinygmula sp.. A large density increase in the fall of 1973 was due to increases of B. bicaudatus and E. albertae. Plecoptera and Trichoptera were secondary contributors to percent numbers and species in the Dollar Creek community. Alloperla sp. and Isogenus sp.

were occasionally common plecopteran representatives while most trichopterans were sparse or rare.

Upper and lower Blackmare Creek (Stations 5 and 6) also reflected summer-fall community fluctuations (Fig. 13,14,15). Common and occasionally abundant mayflies included B. bicaudatus and E. albertae, (Appendix C). Mayflies were the most diverse and abundant group of insects in Blackmare Creek; Plecoptera and Trichoptera were of secondary importance. In the fall of 1972 (Station 6) an increase in percent species was due to increased numbers of Rhyacophila hyalinata Banks, Neothremma sp., Arctopsyche grandis (Banks) and Neophylax sp.. These species decreased in numbers from fall 1972 to fall 1974 (Appendix C).

Diversity values for Blackmare Creek decreased while insect density increased (Table 8). The number of species and insect representatives from each order remained approximately the same (Appendix C). Summer redundancy values increased during the study while a decrease was recorded for the fall samples.

Community Similarity. Insect community comparisons were made for upper and lower intensive stations between years, 1972-74 (Appendicies D-F).

A comparison of bottom samples at upper Trail Creek (Station 1) showed insect communities were most similar for the summer and dissimilar for the fall of 1973 and 1974 (Appendix D). Similar trends were recorded for upper Dollar Creek (Station 3). Summer insect communities at upper Blackmare Creek remained similar throughout the study; fall communities also remained similar but at a higher similarity level.

A comparison of bottom samples at lower Trail Creek (Station 2) show insect communities were most similar for the summer and the fall of

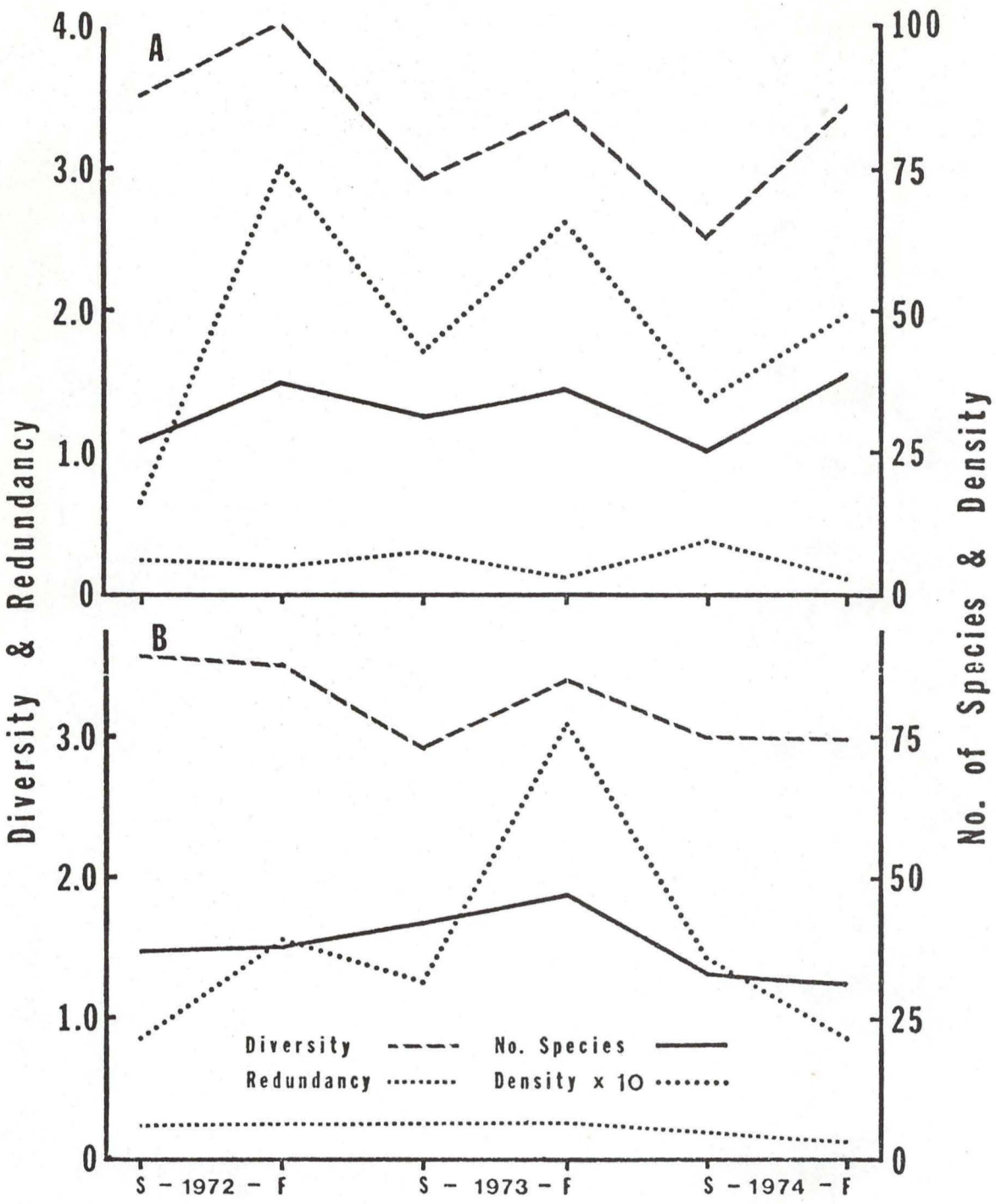

Fig. 11. Diversity, redundancy, number of species and density for Station 1 (A) and Station 2 (B) on Trail Creek, 1972-1974.

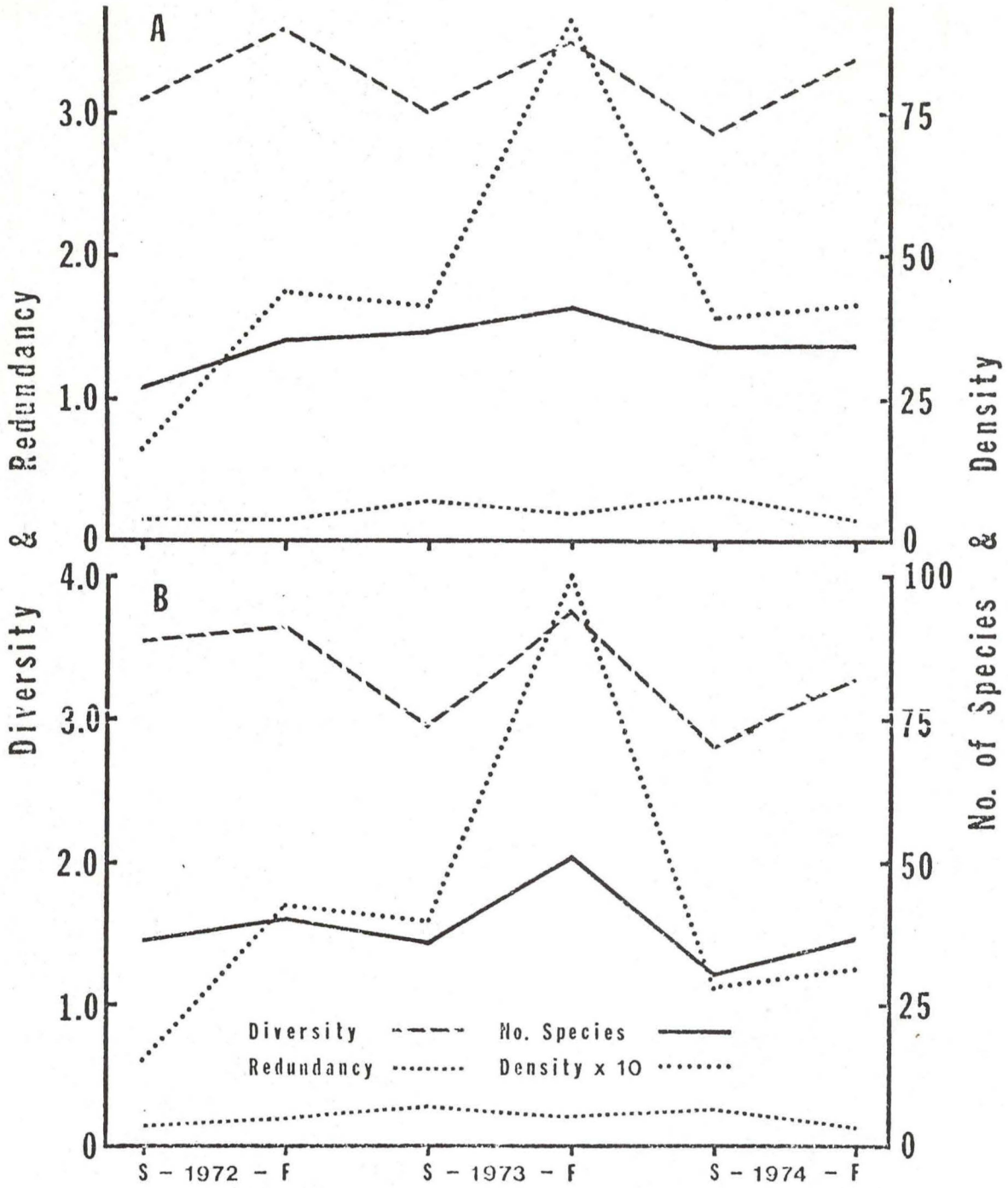

Fig. 12. Diversity, redundancy, number of species and density for Station 3 (A) and Station 4 (B) on Dollar Creek 1972-74.

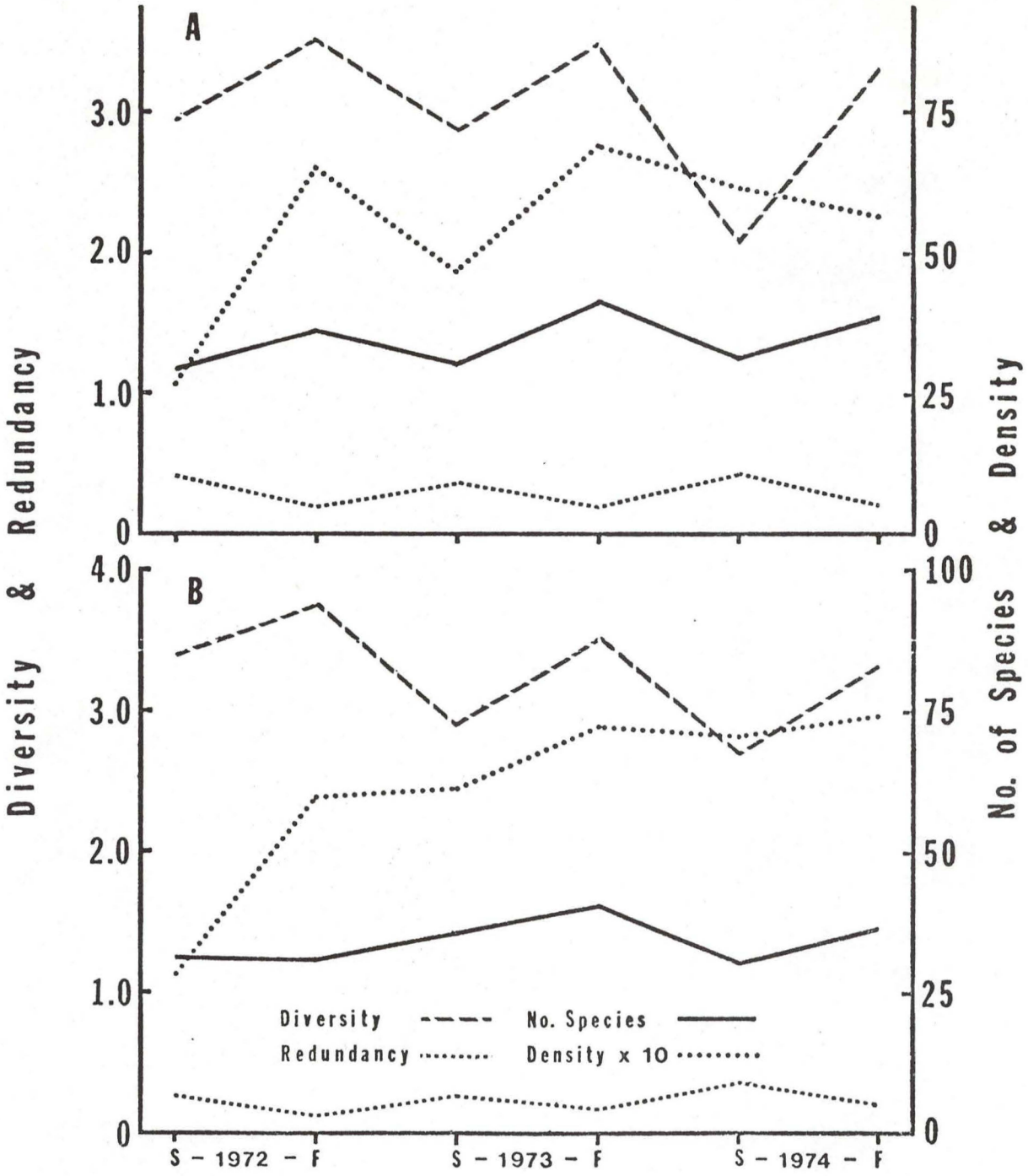

Fig. 13. Diversity, redundancy, number of species and density for Station 5 (A) and Station 6 (B) on Blackmare Creek, 1972-74.

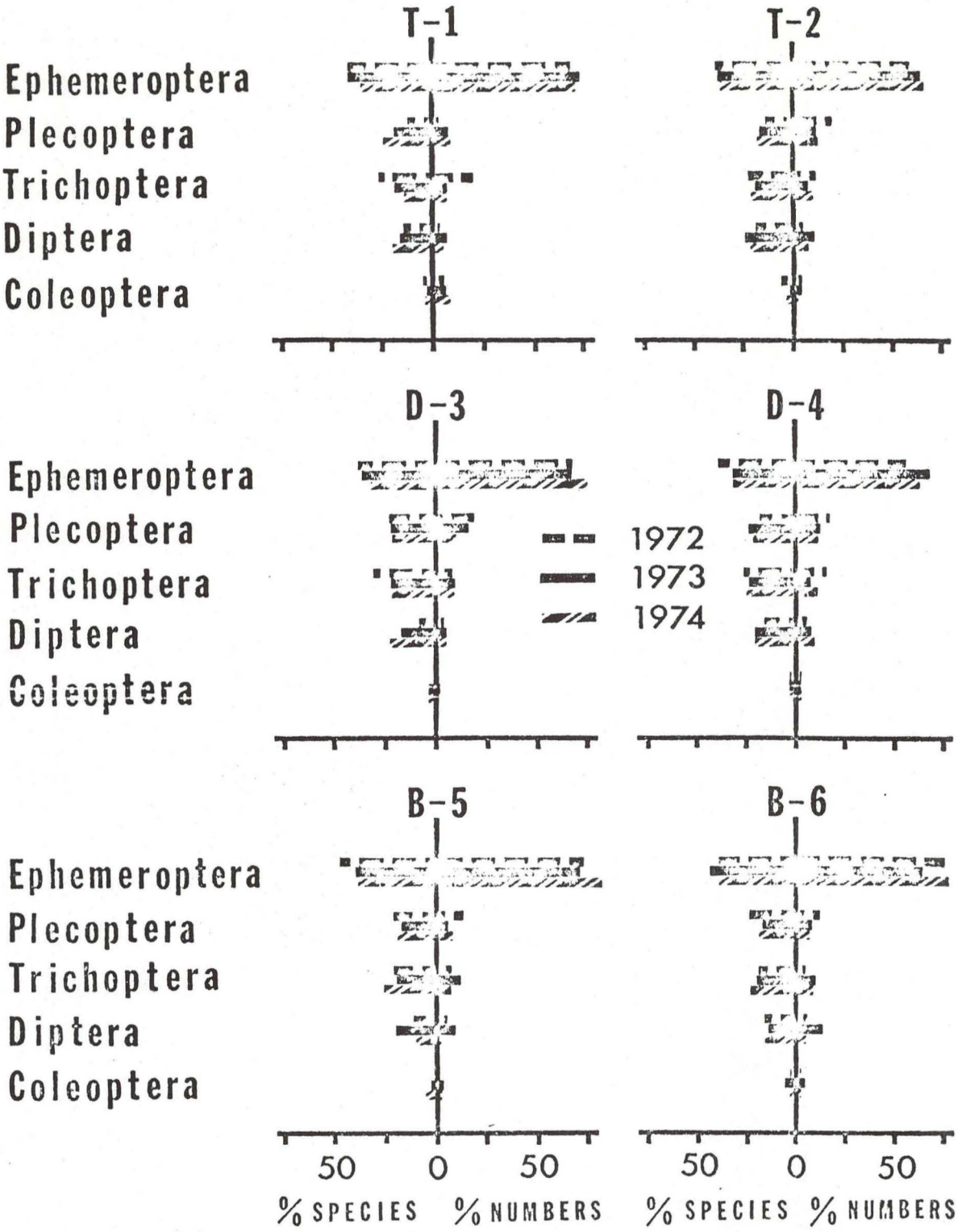

Fig. 14. Average percent total species and percent total numbers for summer bottom samples from intensive study stations. Upper and lower Trail Creek (T-1, T-2), upper and lower Dollar Creek (D-3, D-4), upper and lower Blackmare Creek (B-5, B-6).

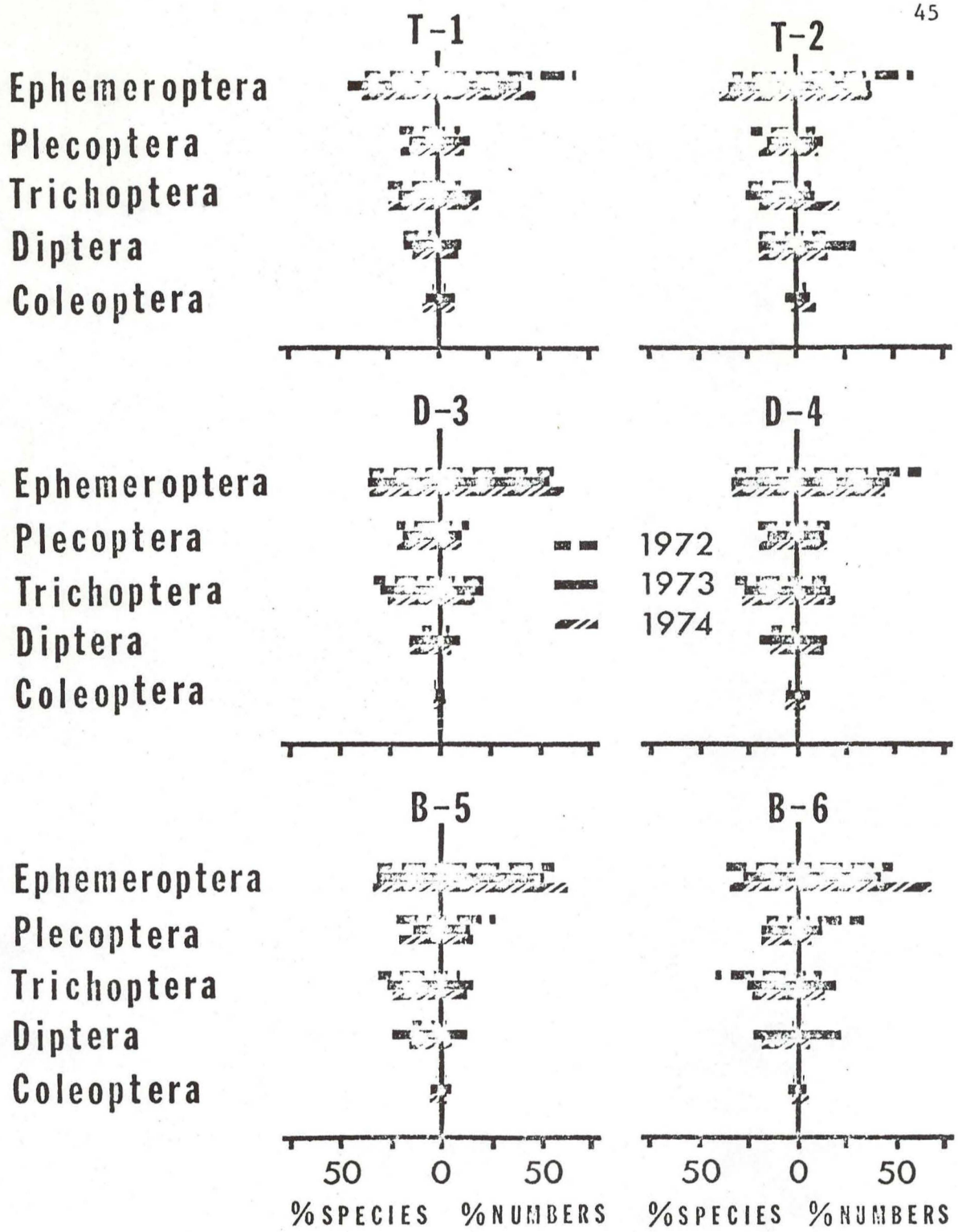

Fig. 15. Average percent total species and percent total numbers for fall bottom samples from intensive study stations. Upper and lower Trail Creek (T-1, T-2), upper and lower Dollar Creek (D-3, D-4), upper and lower Blackmare Creek (B-5, B-6).

1973 and 1974 (Appendix E). Insect communities at Dollar and Blackmare Creeks showed similar trends.

Comparisons of summer insect communities (upper and lower Stations) within streams show Trail Creek stations most similar for 1974 (Appendix F). Dollar Creek stations were dissimilar for this period while highest station similarities occurred in 1973. Highest fall similarities for stations within streams occurred in 1973. Insect communities at Blackmare Creek remained similar at high levels throughout the study.

Cluster analysis of stream communities show distinct clustering (Fig. 16). Fall insect communities in 1972 cluster together while spring samples in 1972 generally cluster independently. Fall communities in 1973 and 1974 also cluster together except for stations 1, 2 and 4 which cluster independently. Summer insect communities generally clustered independently although stations within streams occasionally clustered together at the same sample period.

Faunistic Benthos Analysis. Species composition at the five Dollar Creek "faunistic" stations (D_a-D_e) was similar to Dollar Creek intensive sites (Appendix G). Mayflies were the most abundant insects for all sites during the study.

Diversity was relatively similar at the "faunistic" sites from 1972 to 1974. Density decreased from the fall of 1972 to the summer of 1973, then increased significantly in the fall of 1973; redundancy decreased slightly during the three years (Fig. 17; Table 9). The dominant insects in the community were the mayflies, Rhithrogena hageni Eaton, E. albertae (McDun.) and Ephemerella doddsi Needham. High diversity and density during the fall of 1973 resulted from samples being taken approximately two weeks earlier than in 1972 and 1974 fall

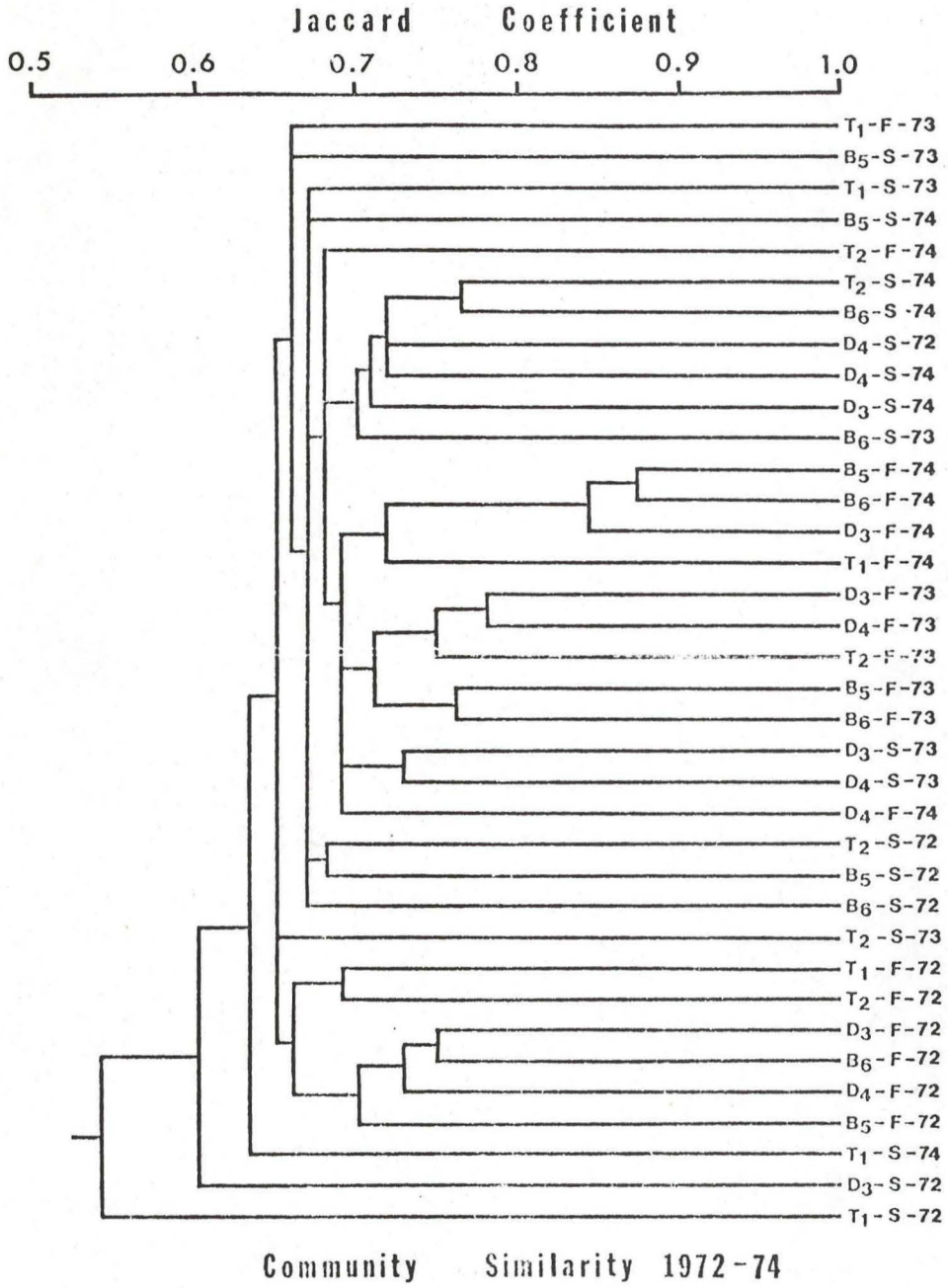

Fig. 16. Community similarity and cluster analysis for summer (S) and fall (F) samples in Trail (T), Dollar (D) and Blackmare (B) creeks (Stations 1-6) in 1972, 1973 and 1974.

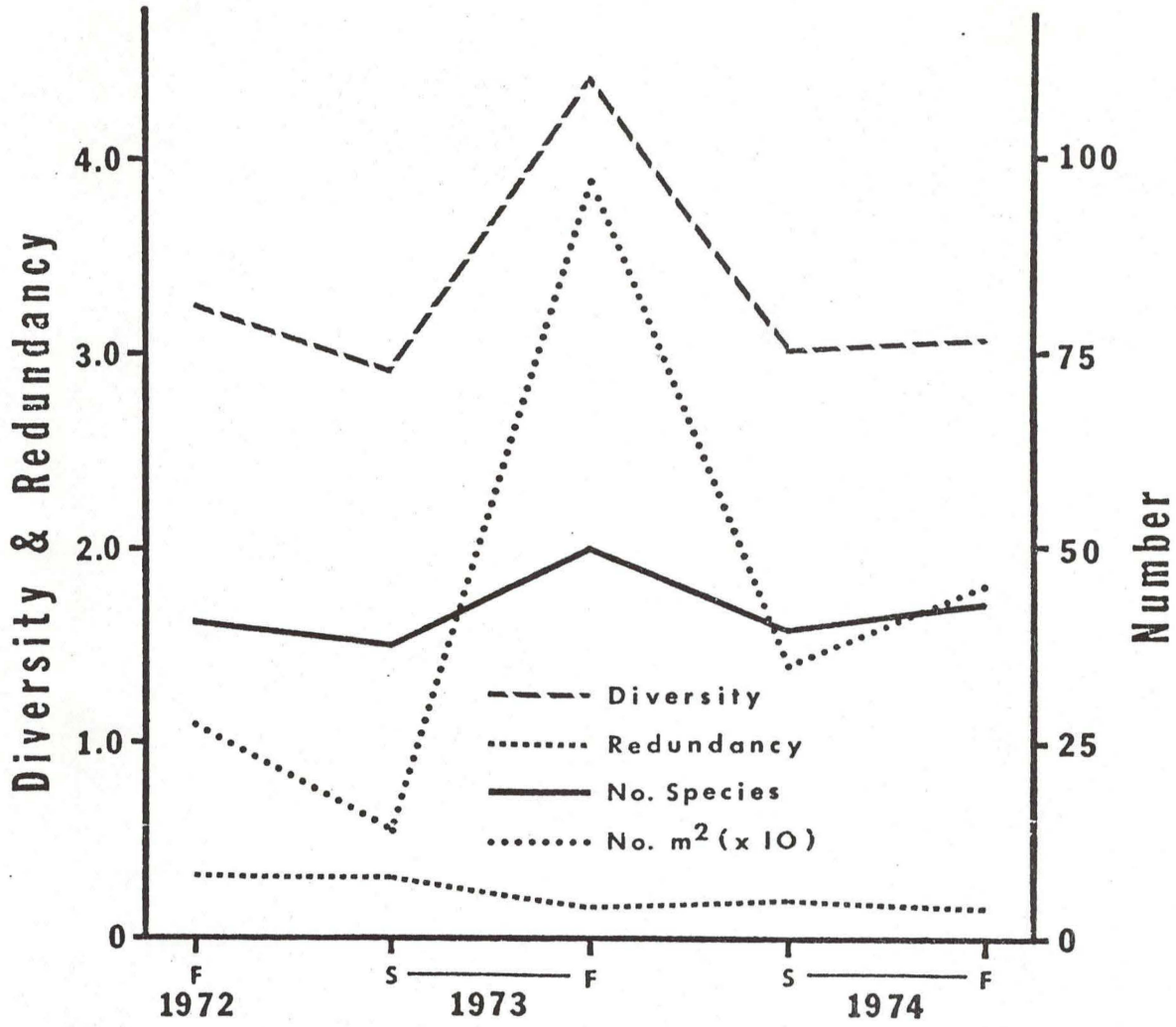

Fig. 17. Bottom sample diversity, redundancy, numbers of species and density at "faunistic stations" for fall, 1972 and summer and fall, 1973-74.

Table 9. Diversity, redundancy, number of species, density and averages for "faunistic" stations of Dollar Creek (D_a - D_e) for summer and fall, 1972-1974.

Date	Stations	Diversity	Redundancy	No. Spp.	No/m^2
Fall 1972	D_a	3.19	0.29	21	344.3
	D_b	3.14	0.26	18	215.2
	D_c	3.29	0.26	23	391.3
	D_d	3.34	0.24	24	248.8
	D_e	3.01	0.25	21	211.1
	Av.	3.25	0.34	39	282.4
Summer 1973	D_a	3.31	0.15	22	240.3
	D_b	3.56	0.16	19	82.0
	D_c	2.89	0.29	19	204.4
	D_d	3.21	0.19	18	164.0
	D_e	1.00	0.00	2	2.6
	Av.	2.93	0.29	37	140.7
Fall 1973	D_a	4.26	0.19	34	1547.6
	D_b	4.37	0.16	38	790.8
	D_c	4.20	0.19	40	862.1
	D_d	4.25	0.19	41	821.7
	D_e	4.40	0.16	41	696.7
	Av.	4.31	0.19	50	918.7
Summer 1974	D_a *				
	D_b *				
	D_c	3.19	0.23	30	399.4
	D_d	2.97	0.23	25	298.5
	D_e	3.22	0.25	32	373.9
	Av.	3.12	0.23	39	357.3
Fall 1974	D_a	3.04	0.14	25	193.6
	D_b	3.01	0.13	29	288.7
	D_c	3.48	0.22	34	449.2
	D_d	3.32	0.20	34	497.6
	D_e	3.22	0.25	37	657.7
	Av.	3.22	0.18	42	436.9

* Samples not obtained.

samples, thus capturing several species of mayflies prior to emergence. These species were also abundant at the Dollar Creek intensive sites. The mayfly R. robusta and caddisflies Parapsyche elsis Milne and R. vepulsa Milne increased in density during the study.

Benthic Community Regression Analysis. Regression analysis was used to correlate the physical stream factors of cobble imbeddedness, dominant substrate, surrounding material and water depth with density and diversity of the insect community (Fig. 18). Density was highly correlated with the imbeddedness of cobble and water depth (Fig. 18; Tables 10-11). It was demonstrated that diversity decreased as factors of cobble imbeddedness and water depth increased. Dominant substrate type and sediment surrounding the dominant substrate were not highly correlated with density; however, density tended to increase as the size of the sediment surrounding the dominant substrate increased (Fig. 18). Density also tended to decrease as the dominant substrate type increased.

The diversity of the insect community was highly correlated with imbeddedness and water depth (Fig. 18; Tables 10-11). Diversity decreased as factors of cobble imbeddedness and water depth increased. Dominant substrate type and sediment surrounding the dominant substrate were not highly correlated with diversity. While not statistically correlated, diversity increased as sediment size surrounding the dominant substrate increased.

Basket Analysis. Basket samples were obtained for intensive and faunistic stations to show relative abundance of the insect community (Figs. 19,20; Table 12). Community composition of baskets at the faunistic stations showed an ordinal distribution similar to basket samples from intensive study sites. Mayflies were the dominant insect group.

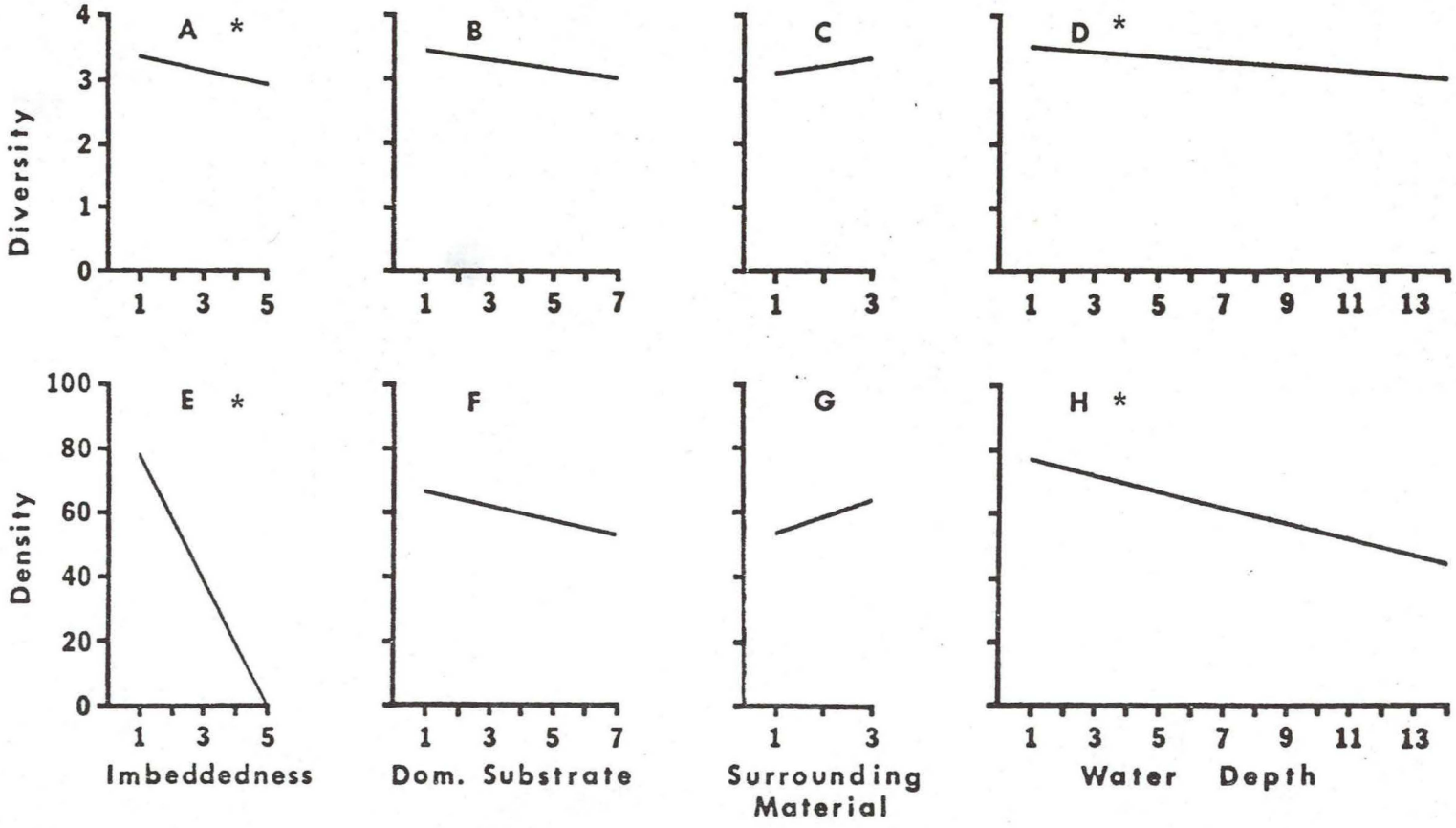

Fig. 18. Regression relationships for diversity (A-D) and density (E-H) per bottom sample in relation to ranked cobble imbeddedness, dominant substrate, sediment surrounding cobble and water depth. *Highly correlated.

Table 10. Correlation coefficients and associated probabilities comparing density and diversity with dominant substrate, imbeddedness, material surrounding cobble and water depth.

	Correlation Coefficients		Probabilities	
	Density	Diversity	Density	Diversity
Dominant Substrate	-0.0559	-0.1108	0.4935	0.1740
Imbeddedness	-0.3791	-0.3791	0.0001	0.0473
Material Surrounding Cobble	0.0295	0.0223	-0.7177	0.7849
Water Depth	-0.1813	-0.2292	0.2054	0.0045

Table 11. Regression coefficients, T values and probability values comparing density and diversity with dominant substrate, imbeddedness, material surrounding cobble and water depth.

	Regression Coefficient		T for HO:B=0		Prob. > |T|	
	Diversity	Density	Diversity	Density	Diversity	Density
Dominant Substrate	-0.05922	-2.25863	-1.36608	-0.68638	-0.1740	0.4935
Imbeddedness	-0.10759	-19.12899	-1.99976	-5.01878	0.0473	0.0001
Material Surrounding Cobble	0.06419	6.42448	0.27339	0.36216	0.7849	0.7177
Water Depth	-0.04265	-2.54923	-2.88461	-2.25807	0.0045	0.0254

Plecoptera and Trichoptera contributed greater numbers and species than obtained in bottom samples at the same sites (Figs. 19,20). R. hageni, Nemoura sp. and Parapsyche elsis Milne were the most abundant insects found in basket samples. E. grandis and E. longimanus (Eaton) were seldom collected in basket samples although often common in bottom samples. Dipterans were also infrequent basket inhabitors. Diversity values for most baskets averaged above 3.00; no major variations in community composition were noted when comparing faunistic basket samples with those from the intensive study sites in 1972 and 1973. Because of human depredation and disturbance of baskets in 1974, a critical evaluation of community characteristics is not possible for all stations.

Canister Analysis. Vertical sampling canisters indicated aquatic insects occurred at depth up to 12" (30.48 cm) in the substrate (Figs. 21-24). Approximately 50% of the insects recovered were found in the lower two levels. Mayflies dominated the upper canister levels while ordinal distribution of insects was more uniform in the lower canister strata. Diversity, density, redundancy and numbers of species generally decreased with increased canister depth (Tables 13-15).

The canisters were inhabited by many of the same species collected in bottom samples (Appendicies A-C). Alloperla sp. and Nemoura sp. were the most common stoneflies and were rather evenly distributed among the three levels (Table 16). Cinygmula sp. and R. robusta were the principal mayfly inhabitants in the canisters, and occurred most abundantly in the top and mid levels.

More insects inhabited the Fall-1973 canisters than in the Summer-1973 (Fig. 22). The mayfly, R. robusta was particularly abundant in the fall samples (Table 16). Diversity values increased with substrate

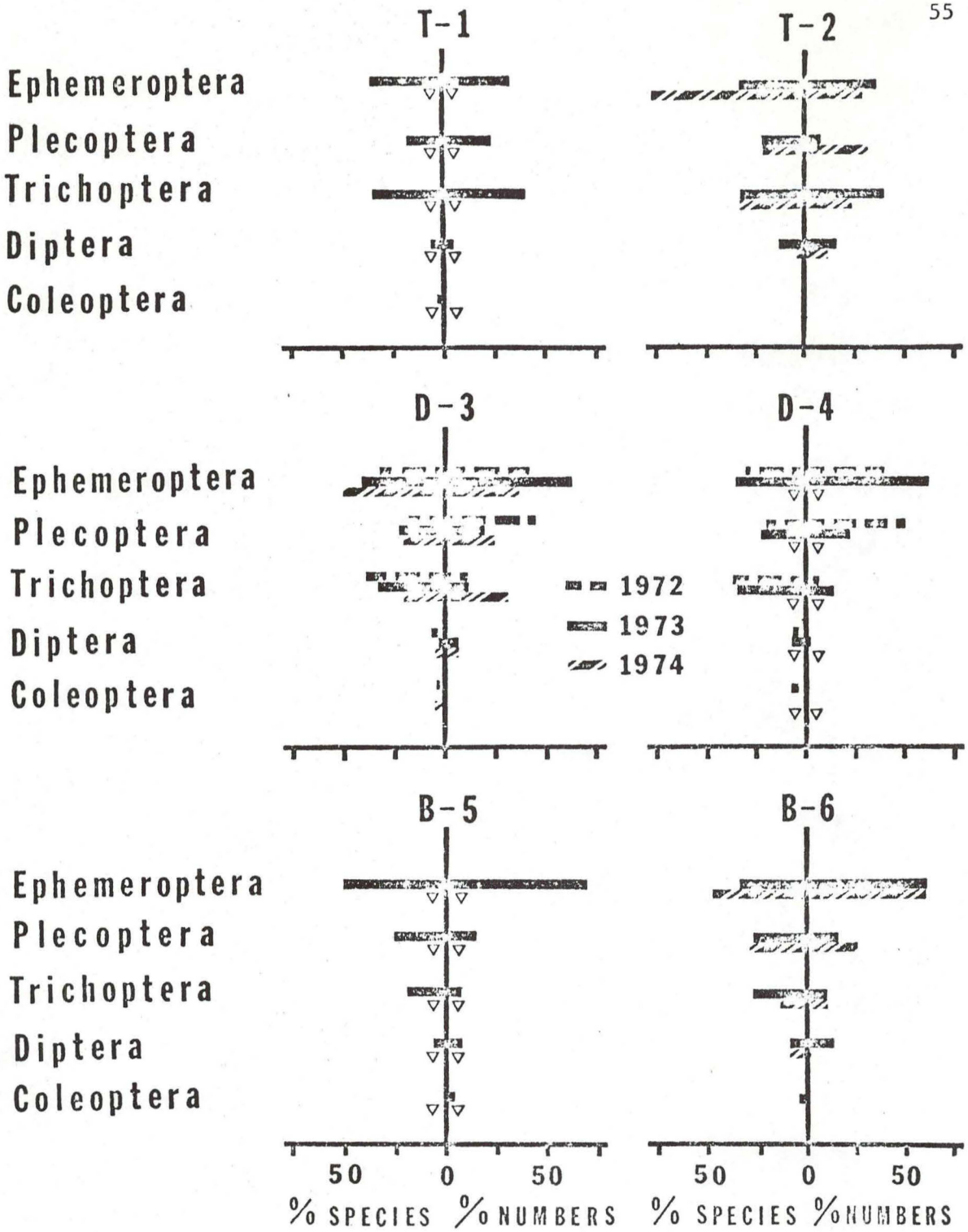

Fig. 19. Average percent total species and percent total numbers for basket samples from intensive study stations. Upper and lower Trail Creek (T-1, T-2), upper and lower Dollar Creek (D-3, D-4), upper and lower Blackmare Creek (B-5, B-6). v = basket lost.

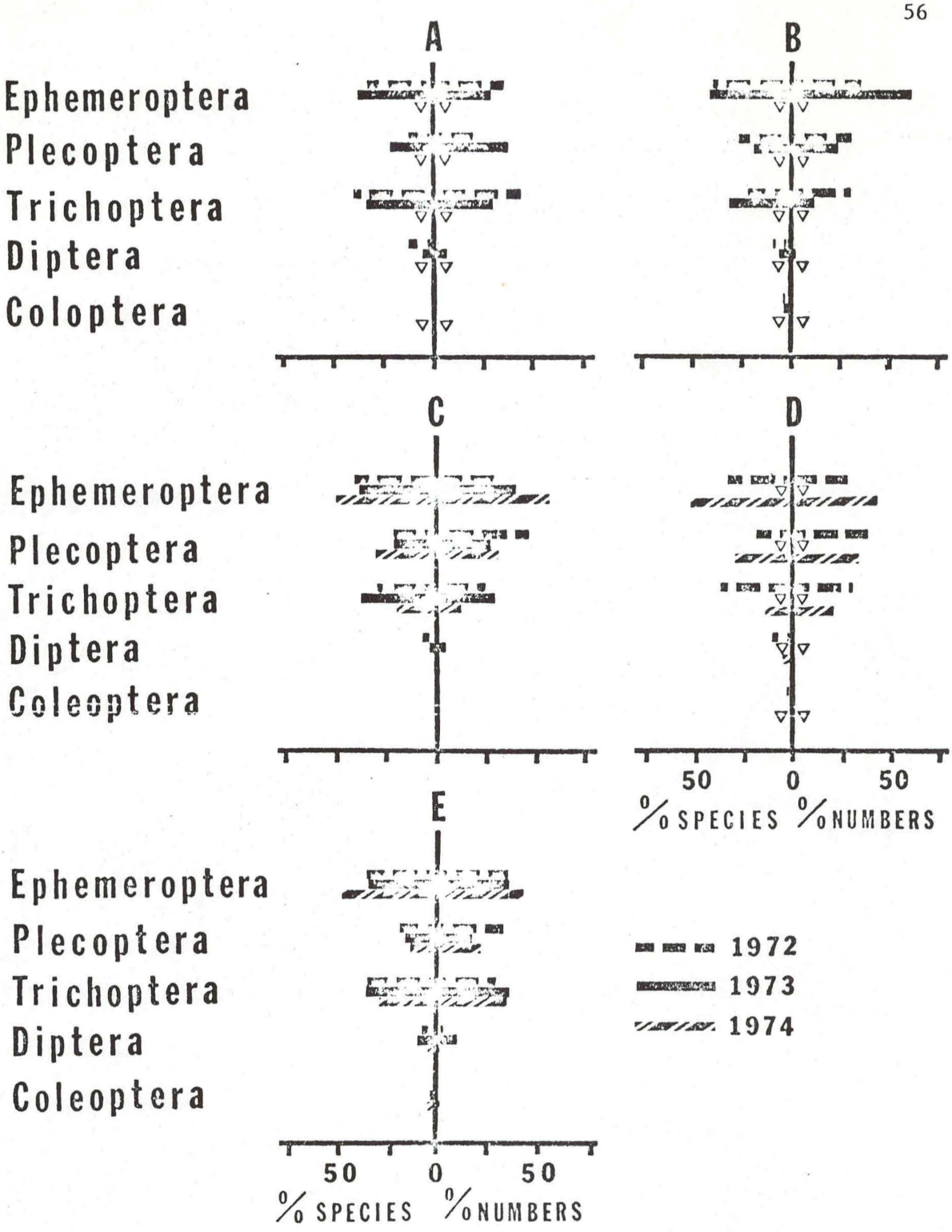

Fig. 20. Average percent total species and percent total numbers for basket samples from "faunistic" sites (A-E) on Dollar Creek. ▽ = Basket lost or sample not obtained.

Table 12. Diversity, redundancy and number of species for baskets at "faunistic" sites (D_a - D_e) on Dollar Creek, 1972-1974.

Year	Station	Diversity	Redundancy	No. Spp.
1972	Dollar Cr. (3)	3.08	0.36	28
	Dollar Cr. (4)	2.71	0.46	30
	Dollar Cr.: D_a	2.65	0.34	15
	Dollar Cr.: D_b	3.04	0.34	23
	Dollar Cr.: D_c	2.95	0.39	27
	Dollar Cr.: D_d	3.27	0.33	28
	Dollar Cr.: D_e	3.45	0.28	26
1973	Trail Cr. (1)	3.72	0.27	31
	Trail Cr. (2)	3.10	0.33	24
	Dollar Cr. (3)	3.61	0.26	27
	Dollar Cr. (4)	2.85	0.41	26
	Blackmare Cr. (5)	3.14	0.23	16
	Blackmare Cr. (6)	3.70	0.21	26
	Dollar Cr.: D_a	3.20	0.37	32
	Dollar Cr.: D_b	3.10	0.40	32
	Dollar Cr.: D_c	3.19	0.35	29
	Dollar Cr.: D_d *			
	Dollar Cr.: D_e	3.50	0.31	31
1974	Trail Cr. (1) *			
	Trail Cr. (2)	3.71	0.21	24
	Dollar Cr. (3)	3.54	0.20	26
	Dollar Cr. (4) *			
	Blackmare Cr. (5) *			
	Blackmare Cr. (6)	3.85	0.06	21
	Dollar Cr.: D_a *			
	Dollar Cr.: D_b *			
	Dollar Cr.: D_c	2.91	0.16	10
	Dollar Cr.: D_d	3.27	0.25	21
	Dollar Cr.: D_e	3.46	0.24	21

* Baskets lost.

depth, a trend which occurred only during this sample period. Ameletus sp., considered a non-borrowing mayfly, was found at all canister levels in Blackmare Creek during the Fall of 1973, but was absent or rare in other sites.

Numbers of insects collected during the Winter 1973-74 were less than earlier sample periods (Fig. 23). Fewer mayflies were found while Plecoptera, Trichoptera and Diptera abundance remained unchanged from earlier Fall-1973 samples. Alloperla sp. was again the most common insect, and found distributed throughout all canister levels (Table 16). Another stonefly, Leuctra sp. commonly occurred in the lower canister strata during this period.

No canister samples were obtained for the Spring-1974 period. Only one canister (Station 1) remained intact after high spring flows of 1974. This canister showed signs of physical disturbance and was partially exposed; therefore was not used for analysis.

More insects were obtained in canister samples during the Summer-1974 than previous sampling periods (Fig. 24). The mayfly, Cinygmula sp., and the stonefly, Nemoura sp., were the most common insects (Table 31). Unusually high numbers of the stoneflies, Nemoura sp. and Acroneuria sp., were obtained from the canister sample at Station 5 (Fig. 24; Table 16).

The accruement of interstitial sediments in the canisters during the time the canisters were implanted, generally increased with canister depth (Tables 17,18). The middle and lower canister levels accrued more sediment than the top; less sediment occurred in the canisters during the Summer 1974 than the Winter 1973-74 sample. These results were consistent for study area streams (Trail, Dollar and Blackmare Creeks) as

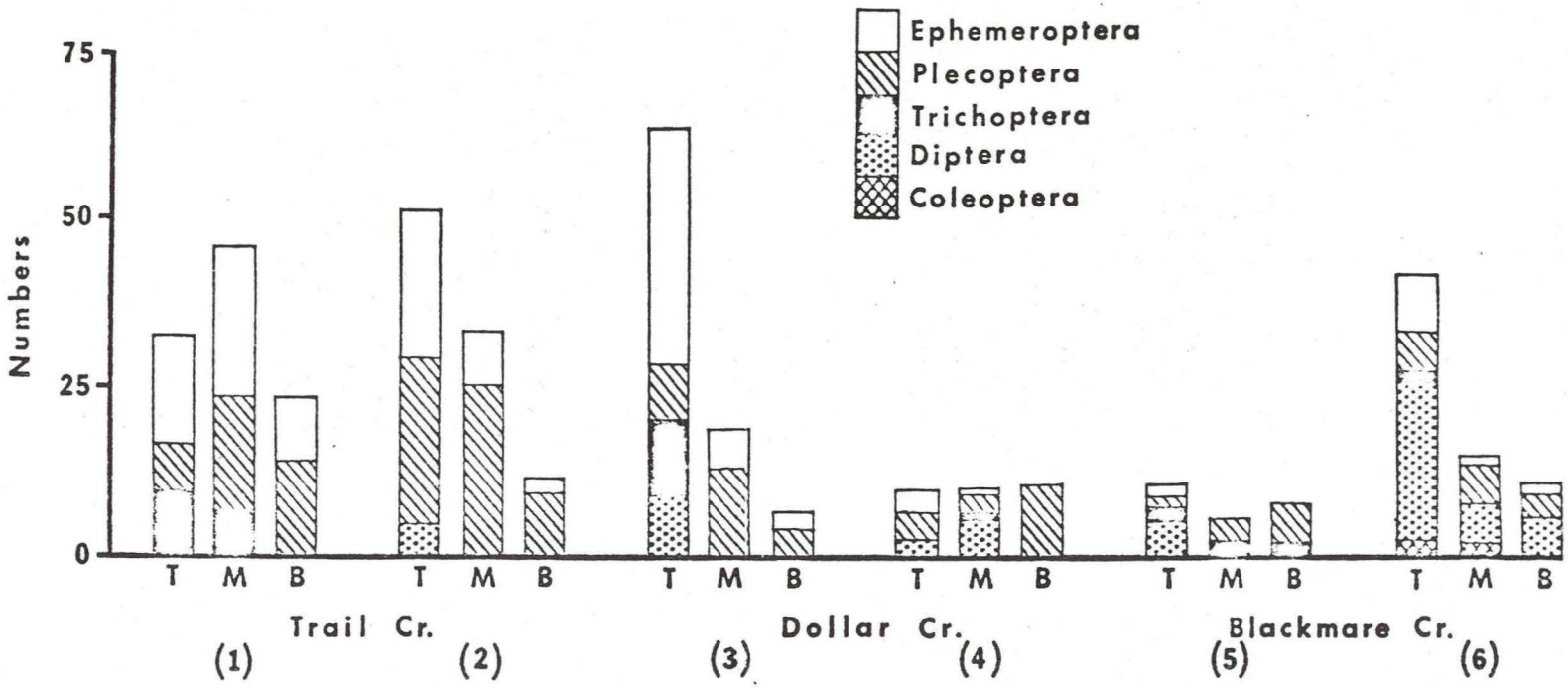

Fig. 21. Numbers of insects per canister level (T, top; M, middle; B, bottom) and ordinal percent contribution at intensive study stations (1-6) from June 27, 1973 to July 18, 1973 (Summer-1973 sample).

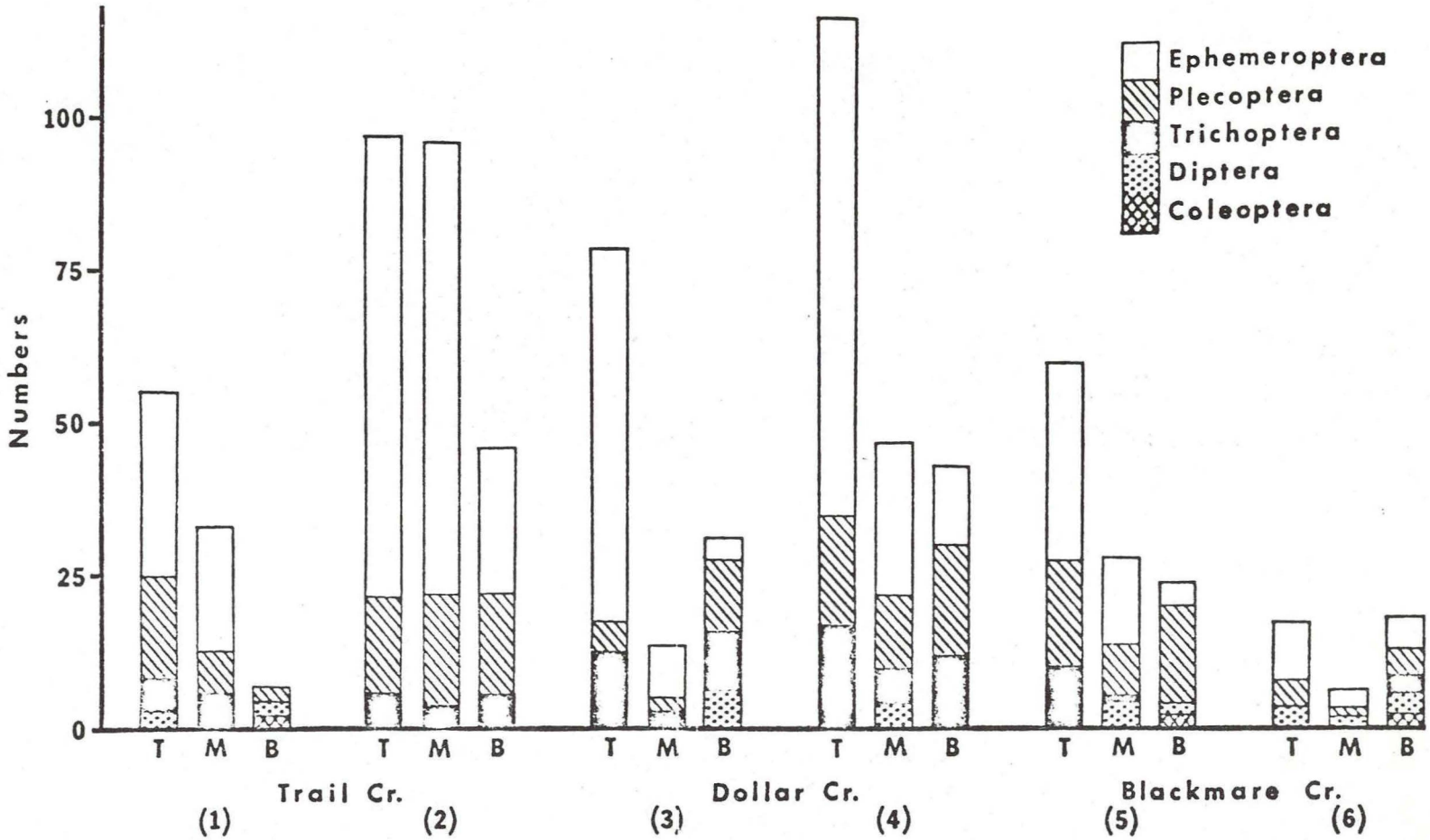

Fig. 22. Numbers of insects per canister level (T, top; M, middle; B, bottom) and ordinal percent contribution at intensive study stations (1-6) from July 18, 1973 to September 5, 1973 (Fall-1973 sample).

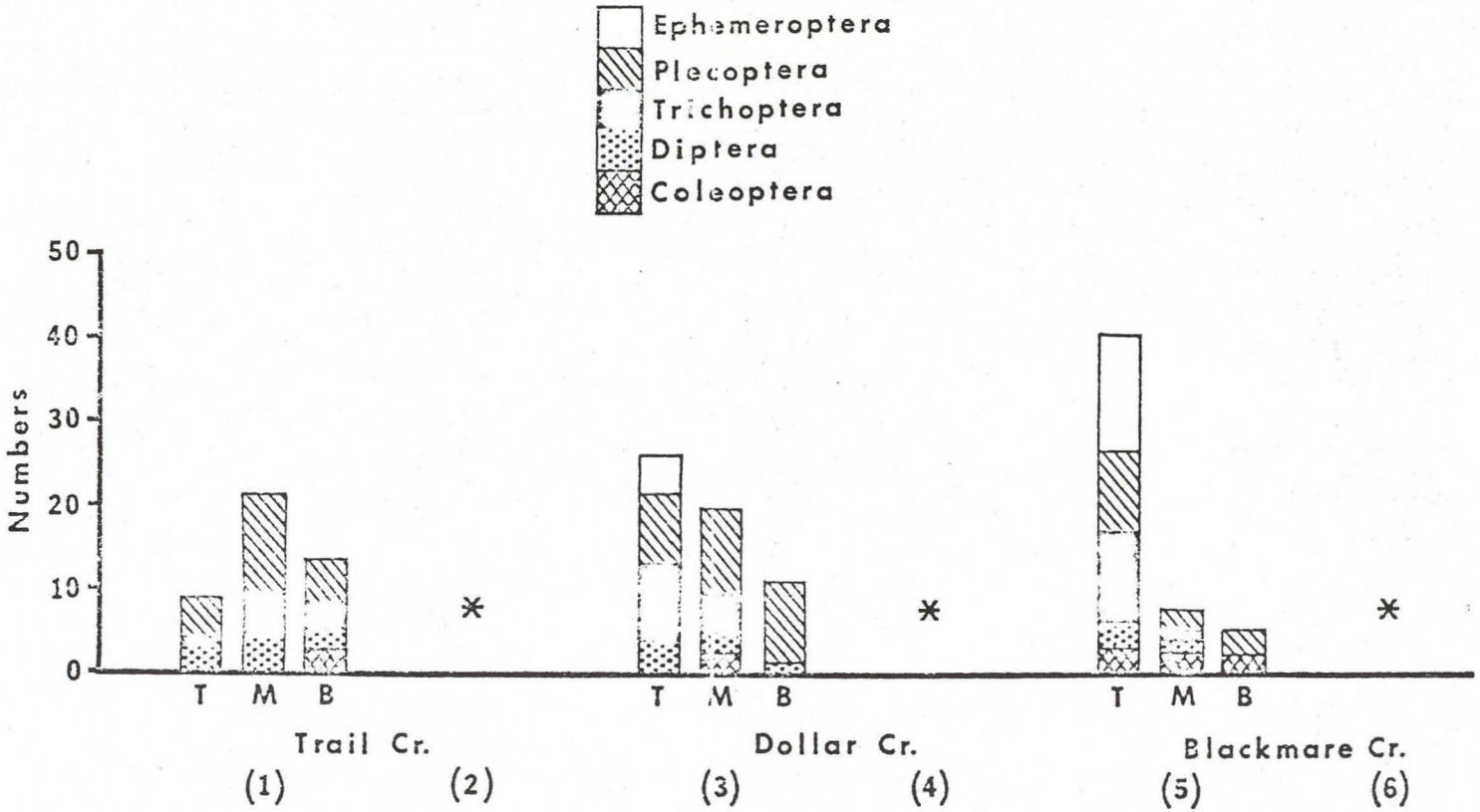

Fig. 23. Numbers of insects per canister level (T, top; M, middle; B, bottom) and ordinal percent contribution at intensive study stations (1,3,5) from September 5, 1973 to May 5, 1974 (Winter 1973-74 sample). *Canister samples not obtained.

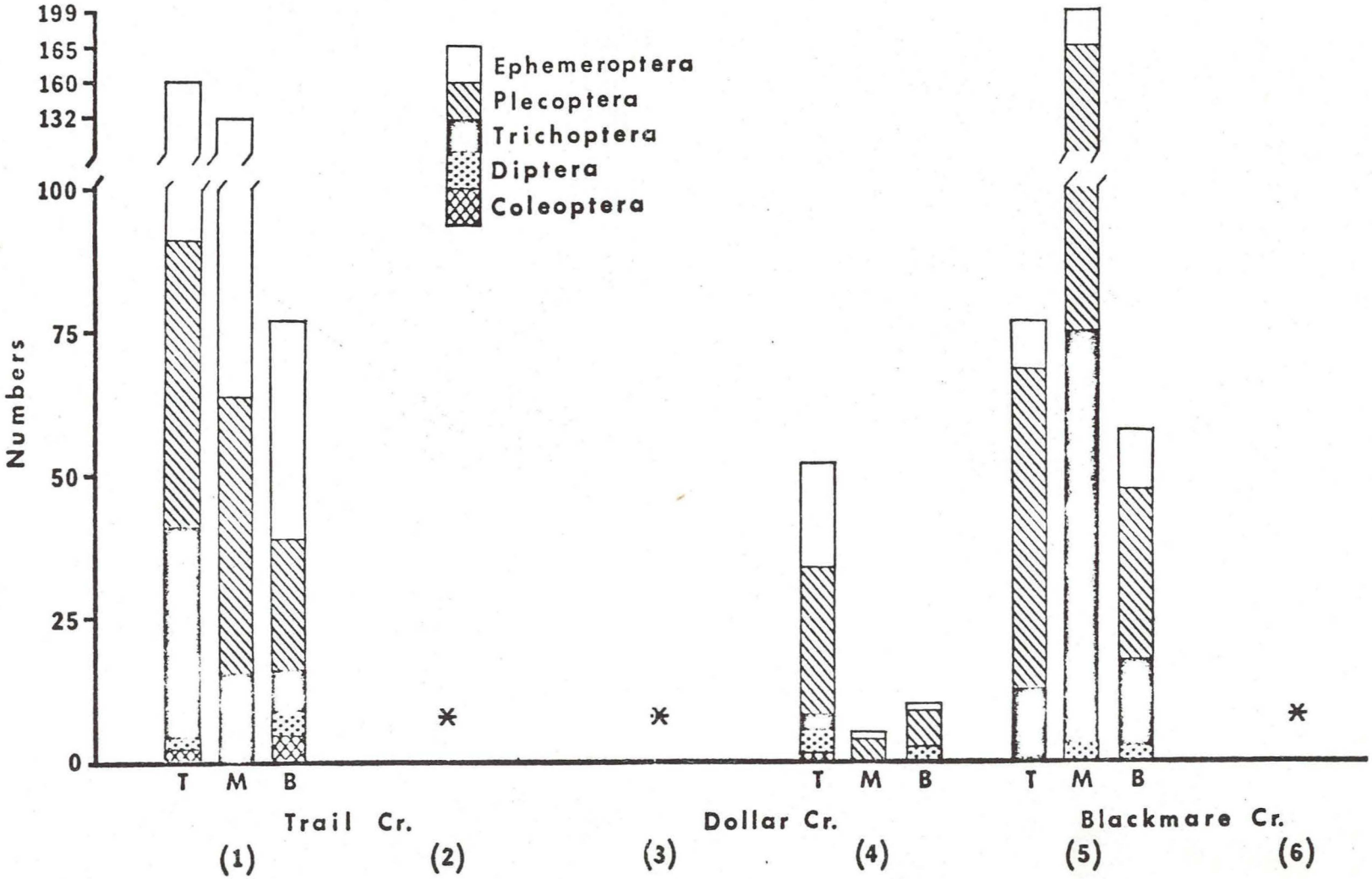

Fig. 24. Numbers of insects per canister level (T, top; M, middle; B, bottom) and ordinal percent contribution at intensive study stations (1,4,5) from July 8, 1974 to September 10, 1974 (Summer 1974 sample). *Canister samples lost.

Table 13. Density, numbers of species, and diversity and redundancy averages for canisters at intensive study sites for Summer 1973.

Stations & Canister Level	Density	No. Spp.	Diversity	Redundancy
Upper Trail Cr. (1) Av.	98	14	2.60	0.20
Top	31	9	2.69	0.21
Middle	44	9	2.70	0.18
Bottom	23	7	2.39	0.16
Lower Trail Cr. (2) Av.	92	9	1.76	0.34
Top	49	9	2.28	0.35
Middle	32	5	1.72	0.32
Bottom	11	4	1.27	0.49
Upper Dollar Cr. (3) Av.	85	17	2.51	0.10
Top	62	16	3.36	0.19
Middle	17	6	2.25	0.16
Bottom	6	4	1.91	*
Lower Dollar Cr. (4) Av.	27	10	2.19	0.10
Top	8	6	2.50	*
Middle	9	6	2.50	*
Bottom	10	4	1.57	0.10
Upper Blackmare Cr. (5) Av.	20	6	1.11	0.26
Top	9	4	1.83	0.05
Middle	4	3	1.50	0.05
Bottom	7	1	0.00	*
Lower Blackmare Cr. (6) Av.	65	17	2.19	0.29
Top	41	12	2.92	0.24
Middle	14	7	2.09	0.19
Bottom	10	4	1.57	0.10

* Because of low numbers of insects, values approximate zero.

Table 14. Density, numbers of species, and diversity and redundancy averages for canisters at intensive study sites for Fall 1973.

Stations & Canister Level	Density	No. Spp.	Diversity	Redundancy
Upper Trail Cr. (1) Av.	92	16	2.34	0.35
Top	54	11	2.68	0.28
Middle	32	9	2.10	0.37
Bottom	6	5	2.25	*
Lower Trail Cr. (2) Av.	236	18	1.98	0.57
Top	96	12	1.49	0.64
Middle	95	8	1.55	0.54
Bottom	45	12	2.90	0.21
Upper Dollar Cr. (3) Av.	120	19	2.21	0.34
Top	77	13	2.32	0.44
Middle	13	5	1.88	0.14
Bottom	30	8	2.43	0.21
Lower Dollar Cr. (4) Av.	202	17	2.39	0.32
Top	115	12	2.21	0.41
Middle	45	9	2.56	0.15
Bottom	42	7	2.40	0.09
Upper Blackmare Cr. (5) Av.	106	21	2.91	0.15
Top	58	13	2.85	0.29
Middle	26	14	3.15	0.21
Bottom	22	9	2.73	0.20
Lower Blackmare Cr. (6) Av.	37	14	2.39	0.08
Top	16	6	2.35	0.02
Middle	4	3	1.50	0.05
Bottom	17	11	3.33	*

*Because of low numbers of insects, values approximate zero.

Table 15. Density, numbers of species, and diversity and redundancy averages for canisters at intensive study sites for Winter: 1973-74 and Summer-1974. Canisters were lost for Stations 2, 3 and 6, Summer-1974.

Date	Stations & Canister Level	Density	No. Spp.	Diversity	Redundancy
Winter 1973-74	Upper Trail Cr. (1) Av.	51	15	2.42	0.25
	Top	10	7	2.52	0.12
	Middle	25	7	2.27	0.15
	Bottom	16	6	2.48	*
	Upper Dollar Cr. (3) Av.	66	19	2.39	0.29
	Top	31	11	2.74	0.25
	Middle	23	10	3.15	0.01
	Bottom	12	3	1.28	0.10
	Upper Blackmare Cr. (5) Av.	63	16	2.12	0.13
	Top	49	15	3.56	0.07
	Middle	8	5	2.15	*
	Bottom	6	2	0.65	0.33
Summer 1974	Upper Trail Cr. (1) Av.	414	30	2.73	0.24
	Top	161	23	3.65	0.18
	Middle	138	15	2.98	0.26
	Bottom	76	17	3.19	0.28
	Lower Dollar Cr. (4) Av.	65	18	2.49	0.15
	Top	51	17	3.49	0.08
	Middle	5	4	1.92	*
	Bottom	9	5	2.05	0.11
	Upper Blackmare Cr. (5) Av.	342	32	3.15	0.27
	Top	75	13	2.36	0.41
	Middle	210	23	3.65	0.21
	Bottom	57	20	3.53	0.22

* Because of low numbers of insects, values approximate zero.

Table 16. Selected species found in canister levels (T=top, M=middle, B=bottom) at intensive study sites (Stations 1-6) during five consecutive sampling periods: Spring-1973, Fall-1973, Winter:1973-74 and Summer-1974.

Order / Species	Station	Summer 1973			Fall 1973			Winter: 1973-74			Summer 1974		
		T	M	B	T	M	B	T	M	B	T	M	B
Ephemeroptera													
Cinygmula sp.	1	3	2								28	10	2
	2	5			1	3					*		
	3	20			5						*		
	4												
	5										1	1	
	6	5									*		
	Totals	33	2		6	3					29	11	2
Rhithrogena robusta Dodds	1	12	12	5	25	19					6	7	2
	2	11	2	1	73	68	14				*		
	3	6	2		43	7					*		
	4				64	13					2		
	5				24	1					3	9	
	6			1	3		1				*		
	Totals	29	16	7	232	108	15				11	16	2
Plecoptera													
Alloperla sp.	1	3	8	9	5	2	1	4	11	4	8	7	12
	2	23	18	8	2		3				*		
	3	4	7	2	1		8	9	4	7	*		
	4	1	2	6		9	10				16	2	2
	5	1	2	7	3	1	8	4	3	5	1	6	9
	6	3	8	6			2				*		
	Totals	35	45	38	16	12	32	17	18	16	25	15	23

Table 16. Continued

Order / Species	Station	Summer 1973 T	Summer 1973 M	Summer 1973 B	Fall 1973 T	Fall 1973 M	Fall 1973 B	Winter: 1973-74 T	Winter: 1973-74 M	Winter: 1973-74 B	Summer 1974 T	Summer 1974 M	Summer 1974 B
Plecoptera													
Nemoura sp.	1	4	8	3	4	1					38	27	6
	2	3	7	1	9	9	7				*		
	3	1	3		5		2		3		*		
	4	2	2		13	2	5				2	1	
	5				1		4				39	60	18
	6	8	1	1			1				*		
	Totals	18	21	5	32	12	19		3		79	88	24

* Canister lost.

well as the St. Maries River in northern Idaho which was studied for comparative purposes. Pebble-sized sediments initially used to fill the canisters remained unchanged. For purposes of analysis, only sediments less than 9.39 mm were considered because of their preponderance in the streambed and facility to fill interstitial spaces of the pebble, thus altering insect microhabitats.

Canister samples in Trail and Blackmare Creeks generally had greater percent fines during the winter pre-runoff period of 1973-74 than the following summer of 1974; the single exception being the bottom one third of the canister in upper Blackmare Creek. Seasonal comparison of canister samples in Dollar Creek was not possible because of loss of samplers or sediments due to human depredation.

Drift Analysis. A total of 55 species representing 39 genera and 5 orders of insects were recovered in drift from 1972 to 1974 (Appendix H).

Ephemeroptera and Plecoptera contributed the largest numbers to drift during 1972 and 1974 (Table 19) while Chironomidae (midges) and Simulium sp. (blackflies) were most prevalent in 1973. Baetis bicaudatus Dodds, B. tricaudatus Dodds, Epeorus grandis and Epeorus albertae (McDun.) were the principal mayfly species while Nemoura sp. was the predominant stonefly (Figs. 25-27). Drift periodicity for all species combined indicated greatest drift at night. Individual taxa, however, drifted at different rates during the daylight and dark hours. A freshet during the 1972 and 1974 drift sampling periods caused some species as Ephemerella tibialis (McDun.), Epeorus grandis Eaton, Epeorus albertae (McDun.) and Baetis bicaudatus Dodds to increase in drift propensity over the abnormally low flows of 1973 (Appendix H).

Table 17. Sediment analysis for three canister levels (top, middle, bottom) in Trail (1), Dollar (3) and Blackmare (5) Creeks. Canister sediment not available for stations omitted. All sediment accrued in the canisters was considered finer than 0.371" (9.39 mm) and represented 100%.

			Canister Level					
			Top		Middle		Bottom	
Date	Station	Sieve Size	% Finer	Wt.(gr.)	% Finer	Wt.(gr.)	% Finer	Wt.(gr.)
Winter 1973-74	Upper Trail Cr. (1)	0.185" (4.69 mm)	66.3	165.0	73.6	449.6	84.5	272.0
		0.093" (2.36 mm)	43.8		56.8		68.0	
	Upper Dollar Cr. (3)	0.185" (4.69 mm)	70.8	354.7	92.5	348.8	83.9	234.3
		0.093" (2.36 mm)	47.0		68.3		68.8	
	Upper Blackmare Cr. (5)	0.185" (4.69 mm)	*		72.2	541.0	65.3	445.4
		0.093" (2.36 mm)	*		61.8		45.1	
Summer 1974	Upper Trail Cr. (1)	0.185" (4.69 mm)	36.7	36.6	52.4	85.7	79.5	76.8
		0.093" (2.36 mm)	24.0		27.3		59.2	
	Upper Dollar Cr. (3)	0.185" (4.69 mm)	*		*		*	
		0.093" (2.36 mm)	*		*		*	
	Upper Blackmare Cr. (5)	0.185" (4.69 mm)	38.7	29.0	53.2	64.4	85.3	97.3
		0.093" (2.36 mm)	20.6		33.6		67.3	

* Sediment samples not obtained.

Table 18. Sediment analysis for three canister levels (top, middle, bottom) in the St. Maries River. Sediment accrued in the canisters was considered finer than 0.371" (9.39 mm).

Station	Sieve Size	Canister Level					
		Top		Middle		Bottom	
		% Finer	Wt.(gr.)	% Finer	Wt.(gr.)	% Finer	Wt.(gr.)
St. Maries River (1)	0.185" (4.69 mm)	44.1	259.5	81.1	310.0	96.7	203.9
	0.093" (2.36 mm)	25.2		67.4		92.1	
St. Maries River (2)	0.185" (4.69 mm)	77.3	261.0	76.7	441.8	85.4	499.9
	0.093" (2.36 mm)	41.7		63.1		76.2	
St. Maries River (3)	0.185" (4.69 mm)	58.5	200.2	71.1	194.6	95.6	310.6
	0.093" (2.36 mm)	41.6		43.1		89.5	
St. Maries River (4)	0.185" (4.69 mm)	00.0	172.1	52.6	215.8	96.7	257.3
	0.093" (2.36 mm)	72.0		23.5		91.4	

Insect drift was over 50% lower in 1973 than in 1972 and 1974. Mayflies and stoneflies were relatively rare drifters while Chironomidae and Simulium sp. contributed the largest numbers. In contrast, dipterans were rare or sparse in 1972 and 1974. In 1974 drift, Trail Creek contained large numbers of R. robusta and Ameletus sp.; Blackmare Creek contained these species but in low numbers in 1974 (Appendix H).

Coleopterans, Optioservus seriatus (LeConte) and Heterlimnius corpulentus (LeConte), were common drifters on Trail Creek in 1972, but rare or sparse during other years (Appendix H).

The trichopteran, Lepidostoma sp. was a common drifter in Trail Creek in 1974, but occurred only at 0300 hours. This species was rare or sparse in Trail and Blackmare Creeks during previous drift sampling periods. In addition, the trichopteran, Rhyacophila acropedes Banks was common in drift in Trail Creek in 1974, but was rare or sparse in drift during previous sample periods (Appendix H).

Diversity for drift on both streams averaged over 3.00; highest values occurred during 1972. Redundancy values for Blackmare Creek were similar for 1972 and 1973, but increased approximately 0.3 in 1974 (Table 19). Drift redundancy values remained relatively constant in Trail Creek during the three years (Table 19).

Table 19. Insect drift for Trail (T) and Blackmare (B) Creeks expressed as numbers/m^3, number of species, diversity, redundancy and total numbers for Ephemeroptera, Plecoptera, Trichoptera, Diptera and Coleoptera, 1972-74.

	Time	No./m^3	No. Spp.	Diversity	Redundancy	Ephemeroptera		Plecoptera		Trichoptera		Diptera		Coleoptera	
						No.	No. Spp.	No.	No. Spp.	No.	No. Spp.	No.	No. Spp.	No.	No. Spp.
T-1972	1900	0.07	17	3.20	0.01	18	7	3	2	6	4			6	4
	2300	0.37	23	3.41	0.21	129	9	21	5	5	3	5	2	18	4
	0300	1.83	31	3.91	0.18	618	15	165	5	19	4	8	2	81	5
	0700	1.24	26	3.44	0.23	456	12	101	4	18	5	6	2	20	3
	1100	0.08	18	3.55	0.01	13	8	4	1	13	5	1	1	6	3
	1500	0.04	10	2.44	0.01	4	3	5	2	6	3			3	2
B-1972	1900	0.08	12	2.61	0.01	19	7	2	1	3	3			1	1
	2300	1.09	22	2.72	0.37	284	10	13	4	6	4	5	1	5	3
	0300	1.63	30	3.23	0.31	381	12	49	5	14	8	9	1	12	4
	0700	1.18	23	3.10	0.27	289	10	30	4	8	5	4	2	6	2
	1100	0.14	12	2.67	0.11	31	5	2	1	4	3	4	2	1	1
	1500	0.14	15	2.98	0.01	19	7	10	2	4	3	4	2	2	1
T-1973	1900	0.16	13	1.88	0.27	10	5	1	1	6	4	36	2	1	1
	2300	0.53	21	3.45	0.19	89	11	15	4	4	2	58	2	6	2
	0300	0.83	27	3.56	0.23	138	13	27	5	12	5	77	2	17	2
	0700	0.52	25	3.20	0.29	73	13	5	1	12	6	58	2	24	3
	1100	0.14	17	2.38	0.19	8	6	3	3	3	4	24	2	8	2
	1500	0.20	12	1.99	0.42	9	4	3	2	3	2	46	2	5	2

Table 19. Continued

	Time	No./m^3	No. Spp.	Diversity	Redundancy	Ephemeroptera		Plecoptera		Trichoptera		Diptera		Coleoptera	
						No.	No. Spp.	No.	No. Spp.	No.	No. Spp.	No.	No. Spp.	No.	No. Spp.
B-1973	1900	0.68	25	3.59	0.18	155	12	11	3	13	5	22	2	12	3
	2300	0.96	30	3.35	0.29	198	13	29	4	21	7	43	3	9	3
	0300	0.61	27	3.07	0.30	123	11	14	3	11	7	35	2	9	4
	0700	0.13	18	3.06	0.07	22	9	2	1	6	5	13	3		
	1100	0.11	12	2.85	0.07	14	6	1	1	2	1	16	2	4	2
	1500	0.06	11	2.58	0.01	8	5	3	2	2	1	6	2	1	1
T-1974	1900	0.06	9	2.37	0.05	19	5			3	2	1	1	1	1
	2300	2.44	24	3.07	0.26	852	8	62	4	25	8	4	2	9	2
	0300	3.17	24	3.30	0.21	986	9	108	5	118	6	22	3	4	1
	0700	1.59	23	3.10	0.28	521	9	62	5	23	6	14	2	2	1
	1100	0.23	21	3.10	0.14	53	5	7	4	18	6	6	3	5	3
	1500	0.15	16	2.98	0.17	31	8	4	2	11	3	9	2	1	1
B-1974	1900	0.94	17	2.14	0.43	265	7	20	4	11	5			8	1
	2300	1.75	19	2.22	0.43	488	7	29	5	35	6	14	1		
	0300	1.70	21	2.10	0.49	466	8	56	5	18	5	6	1	4	2
	0700	1.34	22	2.12	0.52	372	7	37	5	15	5	6	2	4	3
	1100	1.01	19	2.23	0.48	266	7	27	4	30	5	3	2	1	1
	1500	1.00	21	2.00	0.55	288	8	12	3	14	6	8	2	3	2

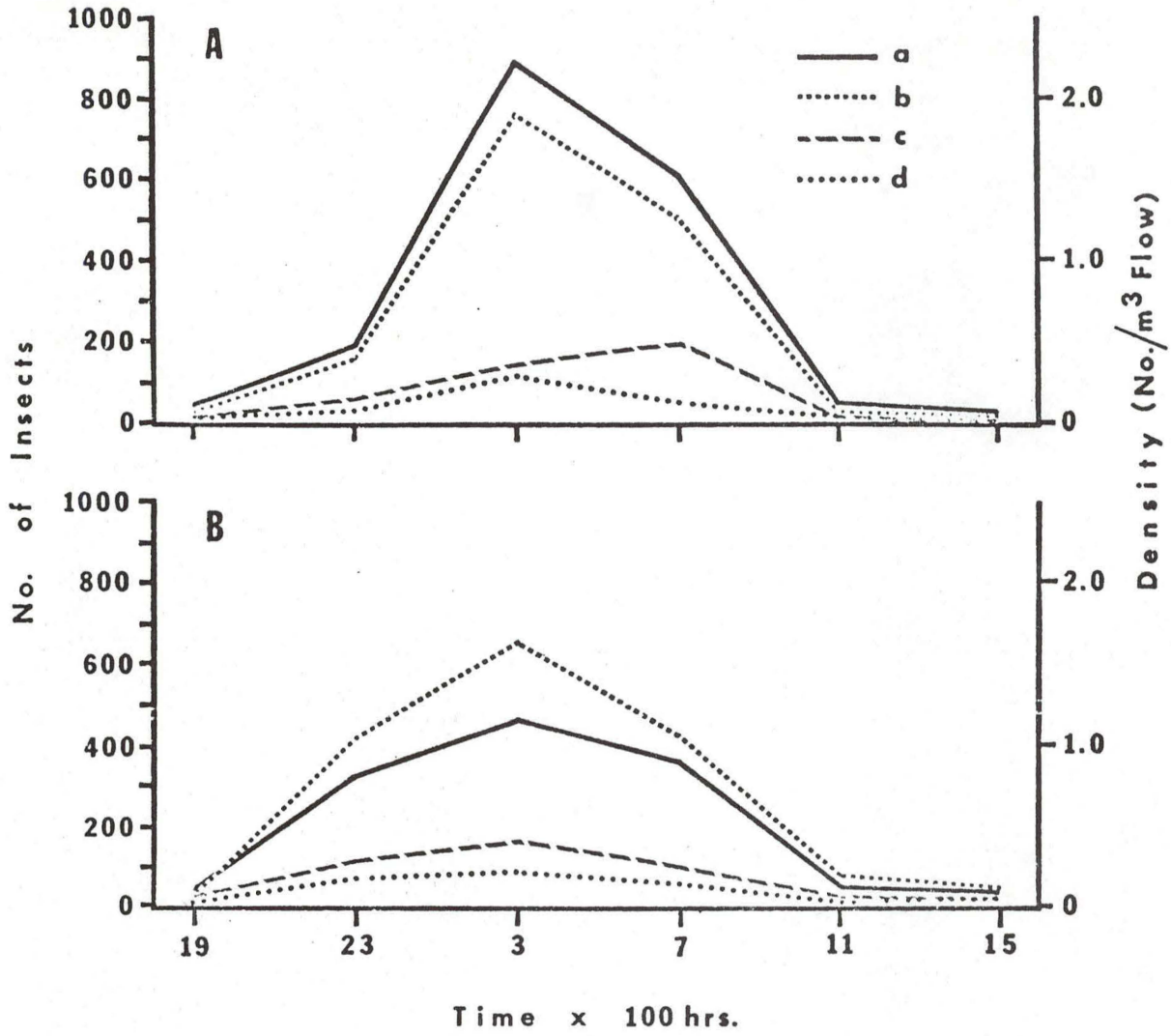

Fig. 25. Insect drift for A. Trail and B. Blackmare Creeks for 1972 indicating a. total numbers, b. total density (numbers/m^3), c. numbers of Baetis tricaudatus Dodds and d. numbers of Epeorus grandis (McDun.).

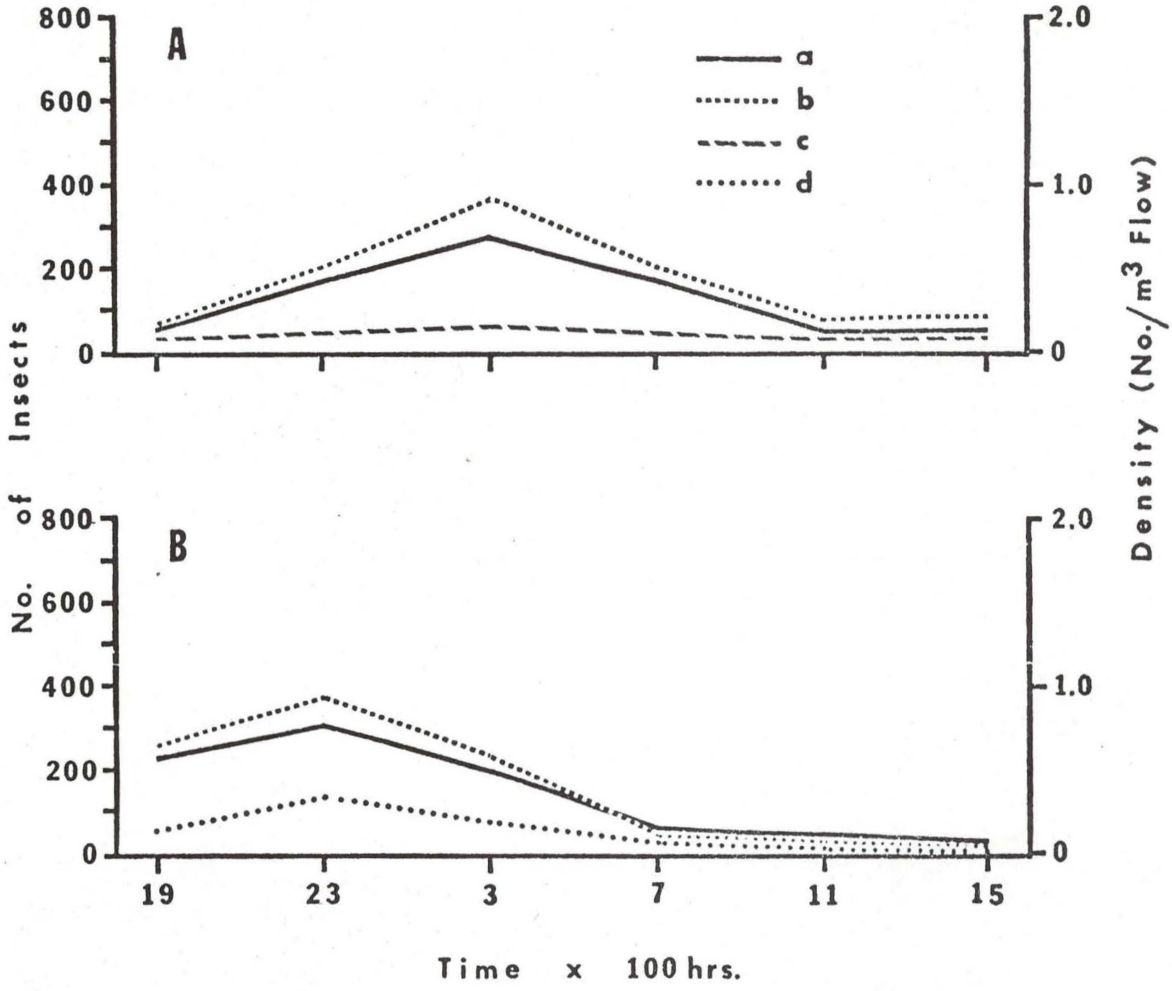

Fig. 26. Insect drift for A. Trail and B. Blackmare Creeks for 1973 indicating a. total numbers, b. total density (numbers/m^3), c. numbers of Chironomidae and d. numbers of Baetis tricaudatus Dodds.

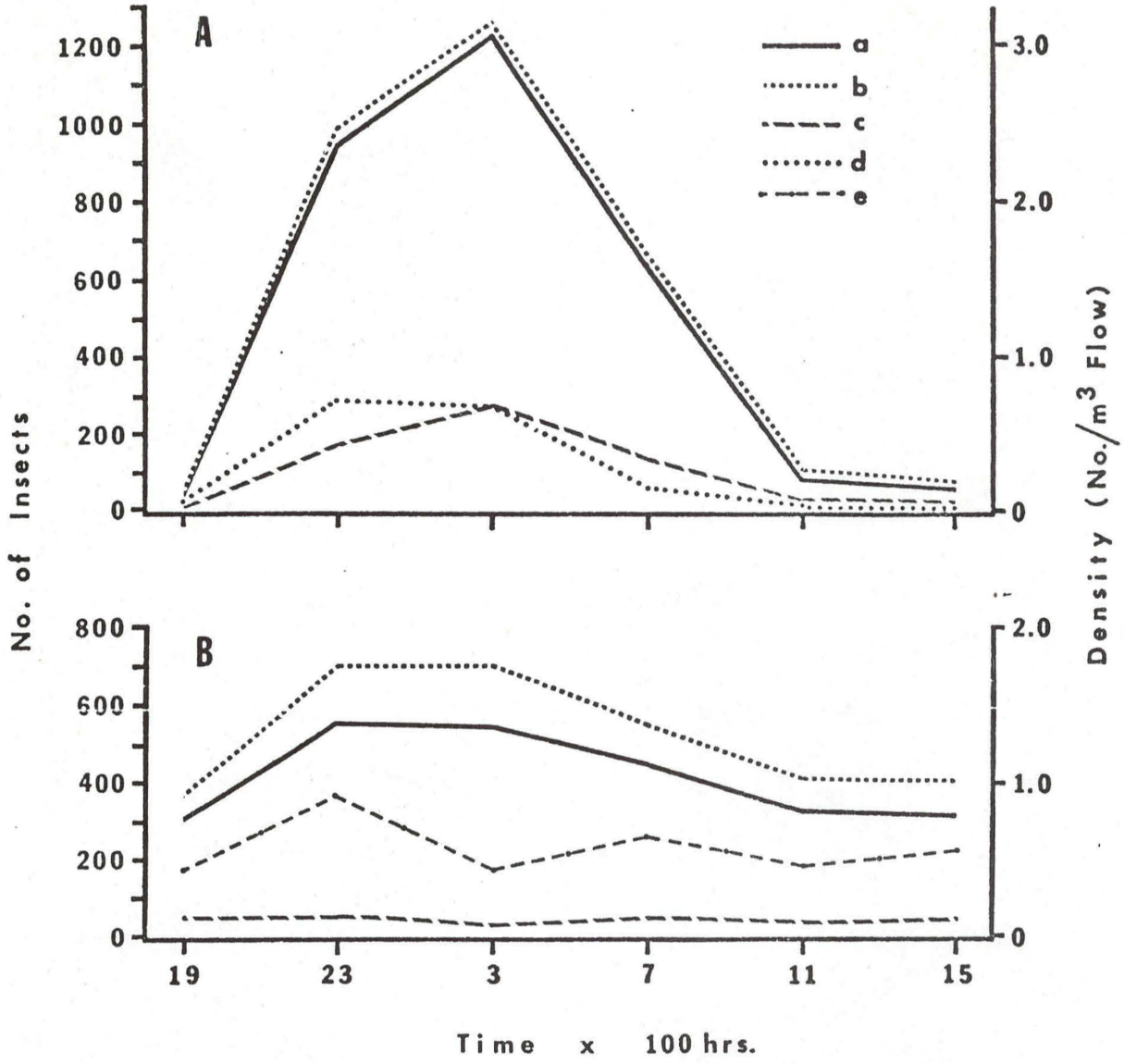

Fig. 27. Insect drift for A. Trail and B. Blackmare Creeks for 1974 indicating a. total numbers, b. total density (numbers/m^3), c. numbers of Epeorus albertae (McDun.), d. numbers of Epeorus grandis (mcDun.) and e. numbers of Baetis bicaudatus Dodds.

Laboratory Study

Drift Simulation Analysis.

Drift simulation studies indicated insect drift increased as sand sedimentation increased for the three insect species tested, Acroneuria californica (Banks), Ephemerella grandis Eaton and Pternarcella sp. (Fig. 28).

A. californica indicated a high drift rate for sedimented and unsedimented conditions and low colonization (Fig. 28A). Less than 10% colonized the introduction zone during the sedimented conditions. Approximately 35% drifted from the test reach with unsedimented substrate, while 60% drifted from the test reach when introduced into moderately sedimented conditions.

The mayfly, Ephemerella grandis Eaton was least affected by sediment among the species studied (Fig. 28C). Approximately 40% of the insects colonized the introduction zone when the substrate was moderately sedimented and approximately 55% during unsedimented conditions. Twenty percent and 5% of the insects drifted out of the test channel when introduced into moderately and unsedimented conditions, respectively.

The stonefly, Pteronarcella sp. was moderately affected by sedimented conditions (Fig. 28B). Approximately 20% and 47% colonized the introduction zone during sedimented and unsedimented tests, respectively. Nearly 50% of the introduced population drifted out of the moderately sedimented channel during a 24-hour test period, while only 15% drifted during an unsedimented test.

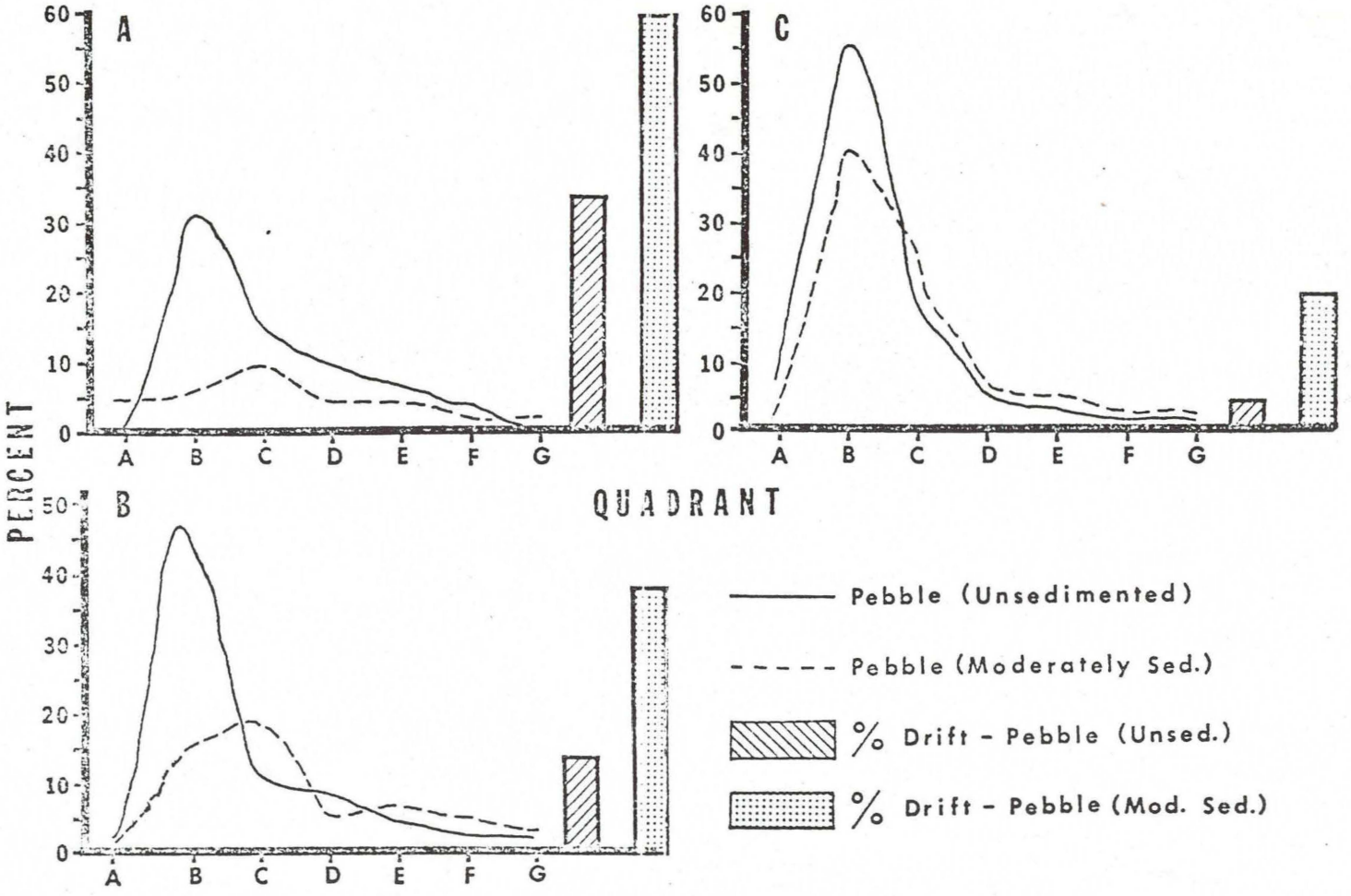

Fig. 28. Percent colonization/channel quadrants and percent drifting from the channel for A. Acroneuria californica (Banks), B. Pteronarcella sp. and C. Ephemerella grandis Eaton when subjected to moderately sedimented and unsedimented conditions.

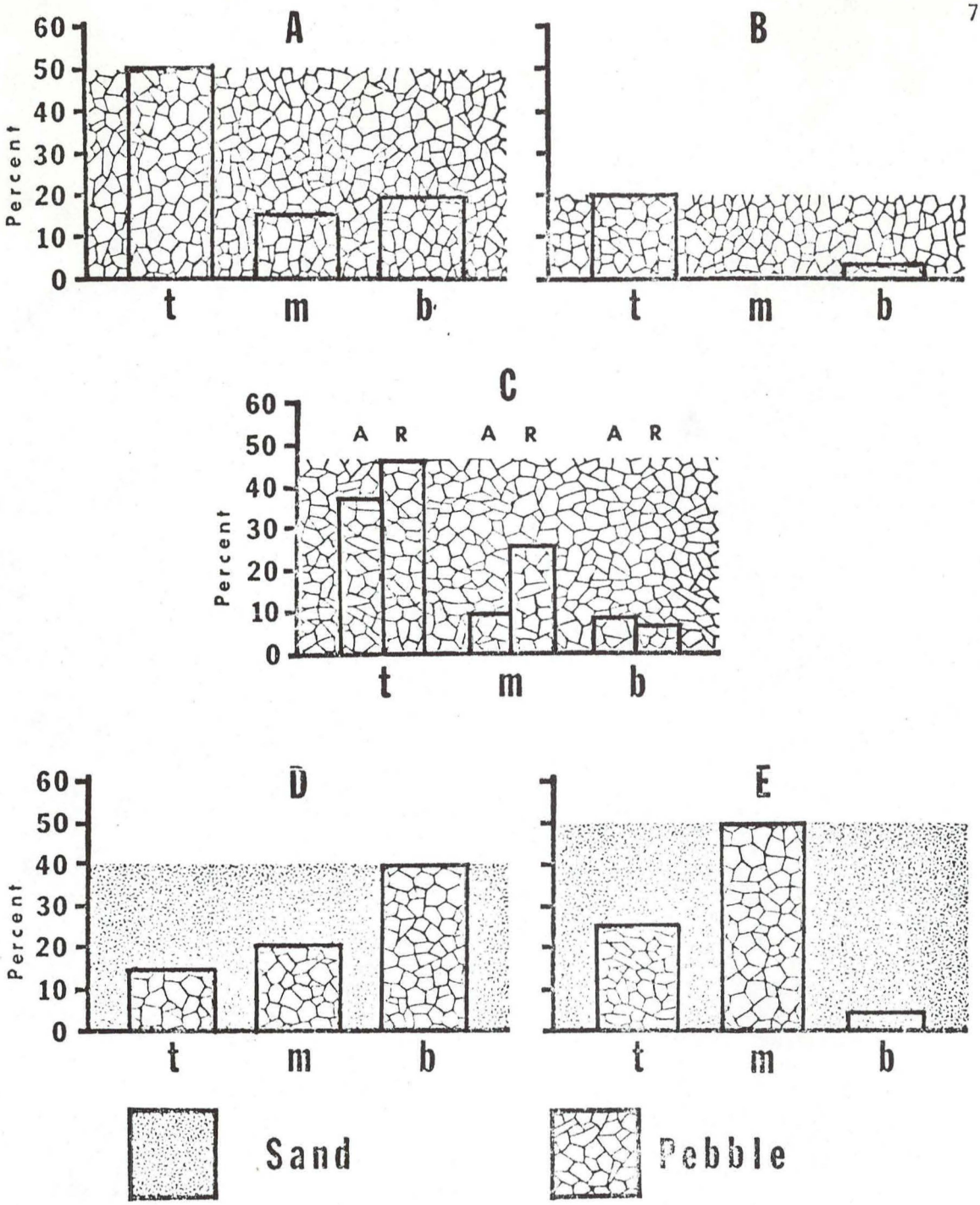

Fig. 29. Laboratory canister simulation with percent present at each level (t, top; m, middle; b, bottom) using Acroneuria sp. (A,D,E), Ephemerella flavilinea McDun. (B) and A-Acroneuria sp. and R-Rhyacophila acropedes Banks combined (C).

Canister Analysis.

Results indicated insects colonized all three substrate levels of canisters under laboratory conditions (Fig. 29). Recovery values do not equal 100% since all of the introduced insects in a quadrant did not colonize the canisters.

Tests using a pebble substrate in and around the canisters indicated most insects remained in the upper canister level (Fig. 29). Approximately 50% of introduced population of Acroneuria californica (Banks) remained in the upper canister level while 10-20% inhabited the middle and bottom levels (Fig. 29A). Essentially similar trends were noted for Rhyacophila acropedes (Fig. 29C).

Most nymphs of Ephemerella flavilinea (McDun.) colonized the top canister level (Fig. 29B). Only 4% were recovered in the middle and bottom levels.

Using a different substrate combination, A. californica was tested using pebble within and sand around the canister. Results indicated a larger percentage of this species inhabited the middle and lower canister levels (Fig. 29 C-D).

Tests using a pebble substrate in the top and middle canister levels and gravel in the bottom level indicated A. californica colonized the top and middle levels primarily (Fig. 29E). Approximately 50% of the specimens were found in the middle level while 25% were found in the top level. The bottom canister level averaged 3% of the total numbers tested.

DISCUSSION

Benthic insect communities are affected by the abiotic stream environment in many ways. Studies have shown that certain physical factors as substrate type, light intensity, stream velocity, imbeddedness, depth and stream order influence benthic distribution (Percival and Whitehead, 1929; Ide, 1935; Linduska, 1942; Lyman, 1956; Cummins, 1962, 1964; Buchannan, 1963; Egglishaw, 1969; Gilpin and Brusven, 1970; Prather, 1971; McClelland, 1972; Barber and Kervern, 1973; Sandine, 1973; Brusven and Prather, 1974; and Hynes, 1974). Hora (1930) indicated that the principle physical condition influencing ecological distribution of aquatic insects is the rate of current flow. Smith and Moyle (1944) reported that the single most important factor influencing bottom fauna production was the physical nature of the streambed. Other important contributions were made in the area of stream ecology by Pennack and Van Gerpen (1947) and Hunt (1930). Cummins (1966) offers a more recent review of work done in stream ecology with a special emphasis on organism-substrate relationships. In most of these earlier studies no quantitive measurement of stream sediments nor cobble imbeddedness were made. In this study the effects of varying sediment-substrate relationships on aquatic insect communities were evaluated, particularly as they pertain to Idaho Batholith conditions.

Insect-sediment Associations.

Substrate Dynamics. Sediment is a ubiquitous pollutant which poses many problems in estimating its quantity in a watershed and its

effects on the aquatic biota. Four billion cubic yards of sediment find their way into water courses in the U.S. annually (Gammon, 1970). Approximately 128,800 tons of sediment was reported introduced into the South Fork drainage prior to rehabilitation (Arnold and Lundeen, 1968).

The Idaho Batholith presents special problems in sediment pollution. The decomposed granite, which characterizes the South Fork area, readily disintegrates into coarse granular particles which then become part of the stream bedload. Bedload sediment is defined in this context as the sand-gravel complex which is loose and moves by saltating along the channel bed.

Core samples taken from South Fork tributaries to a depth of 12" (30.48 cm) showed that over 40% of the sediments ranged from small pebble to silt. Over 30% of the sediments were pea gravel and fine sand. Jensen (1966) indicated 80% of the soil in Zena Creek drainage in the South Fork was sand and gravel. Core samples from Trail, Dollar and Blackmare Creeks contained over 40% of this size material and became an important part of the streambed sediments. Much of this material is loose and mobile on the streambed surface; finer sediments infiltrate the deeper strata causing serious mortalities among salmonid embryos and fry in the gravel (Mickelson et al., 1973).

Based on data from this study, the average imbeddedness factor of cobble was approximately 1/4 for the study tributaries of the South Fork Salmon River. It is recognized that this value may change seasonally and annually because of differing water transport energies. Sandine (1974) reported that cobble imbeddedness was not a critical factor in aquatic insect distribution until cobble became approximately 2/3 imbedded. Gammon (1970) reported no statistical difference in

diversity of insects on light to moderately sedimented riffles. Findings from this study indicate the cobble imbeddedness values and general substrate conditions during the summer months in the tributary study streams were not seriously detrimental to aquatic insect communities.

Stream discharge is a principle factor influencing substrate character. Brusven et al. (1974) reported that the sediment transport capability of a stream is influenced by slope and discharge. As stream flows decrease sediments settle out and subsequently affect the rhithron and hyporheal. The rhithron used in this context refers to the streambed surface while the hyporheal is that life zone beneath the streambed where water percolates slowly between the stones and gravel.

It was demonstrated in this study that insect density and diversity had a high correlation with the physical parameters of cobble imbeddedness and water depth. The sediment surrounding the cobble, a parameter inseparably related to imbeddedness, also influenced density and diversity. As the particle size of sediment surrounding cobble increased, density and diversity increased suggesting that fine sand and silt adversely effect benthic distribution and abundance. Hynes (1970) and Brusven et al. (1974) indicated diversity and often density is reduced in streams having an abundance of sands. Surrounding material was not highly correlated with density and diversity because of the restrictive character of sediments available for study, i.e. the full range of sediments included in the surface-sediment rank classification were not always available for sampling.

Insect diversity and density decreased as dominant substrate type increased. The substrate types were evaluated within the confines of the Hess bottom sampler and generally consisted of material smaller

than large cobble and boulder. The physical constraint of the Hess bottom sampler precluded establishment of definitive insect-substrate relationships among large substrate types.

Substrate type, gradient, discharge, depth and other physical stream parameters were essentially the same for all study streams. Upper study stations of each tributary were dominated by large cobble and boulder while the lower stations were predominately small cobble and pebble. Stream profiles showed that large cobble and boulder substrates were less effected by high flows than small cobble substrate. Seasonal subsurface sediment and flow changes were not monitored, but are assumed to have occurred. Subsurface flows through streambeds have been measured by Gangmark and Bakkala (1958) and Pollard (1955) and are considered important to the hyporheic fauna. Findings from this study and others suggest that small sediment particles tend to penetrate the intersticies restricting the micro-distribution of benthic insects.

Upper and lower stations within a study stream had similar insect communities. Trail and Dollar Creeks had greater yearly fluctuations in density and diversity than Blackmare Creek, even though substrate parameters were similar. Blackmare Creek, which was pristine, had least community variability between years and reflected greater habitat stability.

Low insect densities at lower Trail Creek (Station 2) in the fall of 1974 were attributed to an increase in sand and reduction in velocity. An unauthorized rock-soil dam constructed at the upper end of the station created a shallow pool condition, thus greatly altering the habitat and the benthic community.

In the fall of 1973, density, diversity and numbers of species

increased in the tributaries from previous fall samples. This condition is believed to have been caused by taking samples approximately 2 weeks earlier than during the previous year. Many large nymphs were collected which normally would have emerged had the sampling been delayed. A reverse trend occurred in the summer of 1972. Low insect densities in tributary streams suggested a major emergence prior to sampling. Nymphal age-class comparisons indicated many species emerged during mid-June while others emerged in early September. Spring and late summer are considered principle emergence times for insect in many streams (Hynes, 1972).

The substrate classification scheme used during this study generally proved effective in establishing insect-substrate relationships. The parameters of cobble size, imbeddedness of cobble and size of material surrounding cobble were obtained for each bottom sample. This technique provided an important inter and intrasample evaluation of physical and biotic conditions. Cummins et al., (1964) suggested that substrate is a good characteristic to use as a basis for a system of "ecological typing", even though variations occur in faunal composition on certain substrates at different localities.

Insect Behavorial Response to Changing Substrate Conditions. Insects represent one of the most diverse groups of organisms on earth. Their wide ecological and biological adaptations have permitted colonization of almost all known habitats. Among the stream inhabiting forms are filter feeders, scrapers, carnivores, opportunists, etc. that have unique morphological attributes allowing maximum niche exploitation. For years researchers in aquatic ecology have considered primarily the

benthic life in shallow, surface sediments of the streambed. This study has shown that an additional life zone exists below the substrate surface. This zone is an important part of the complex stream ecosystem, especially in Idaho batholith streams where large seasonal and annual changes in flow and bedload occur.

Recovery of insects from the hyporheal in the study streams indicated that vertical migration of aquatic insects is a dynamic part of the complex benthic community inhabiting the South Fork tributaries. The most common orders of insects represented were Ephemeroptera, Plecoptera and Trichoptera. Mayflies dominated the top and middle canister levels while stoneflies and caddisflies generally dominated the bottom strata. Several workers have obtained similar trends (Angelier, 1953, 1962; Schwoerbel, 1961, 1964; Berthelemy, 1968; Hynes and Coleman, 1968; Hynes, 1968; Radford and Hartland-Rowe, 1971).

The granitic substrates of the batholith offer a unique habitat for aquatic insects. As previously discussed, decomposed granitic sands and gravels enter the stream to become a seasonal component of the streambed. Analysis of accrued sediments in canister samples indicated finer sediments occupied the lower stratum and influenced insect colonization. Sediment accumulations increased during the winter and decreased during the summer suggesting a degree of subsurface flushing of fine sediments during high spring flows. This condition occurs especially during record flows. Subsurface conditions in riffles are more dynamic and subject to greater changes than pools or runs (Dr. Fred Watts, Univ. of Idaho College of Engineering; personal communication). Subsurface considered in this context is the top 12" of sediment lying just beneath the streambed-water interface. Riffles are the most productive areas of

insect growth and development.

The difficulty and often times inability in measuring the physical phenomena of sediment composition and permeability precludes definitive microenvironmental analysis of insects in most instances. It is recognized however, that the streambed composition and subsurface flow characteristics are of vital importance to benthic life in streams, especially as they influence movement and respiration.

The life zone of the hyporheal is a complex dynamic zone in which insect-sediment relationships are very important. The data from this study indicate that the hyporheal offers a "faunal reserve" which aids in the replenishing of insects lost from the rhithron during high flow conditions and natural drift.

Density fluctuations of hyporehic communities of the South Fork tributaries were generally attributed more to spacial effects of insect development than sediment accruement in the sampling canister. This was evident by decreased numbers of insects inhabiting the canisters during the winter of 1973-74 than during the summer of 1973 and 1974. It was determined during this study that sediment accruement in the canisters was not sufficient to prohibit insect colonization for most species during the sampling periods. It must be recognized, however, that a lack of information exists regarding the ecology of the egg and early nymphal stages. The ecology of these early developmental stages needs to be fully understood before extensive ecological interpretations can be made regarding their distribution in the hyporheal.

Canister simulation studies, using selected species, showed insects responded to various sediment conditions. Acroneuria sp. inhabited all three sub-levels when using unsedimented pebble in the canister and as

a surrounding substrate; larger numbers were, however, recovered in the top. When sand was introduced around the canisters, largest numbers of Acroneuria sp. occurred at the middle and lower levels, thus suggesting sand abrasion occurred at the top canister level stimulating an avoidance reaction in Acroneuria sp. causing a deeper vertical migration.

Canister samples at upper Blackmare Creek, after record high flows of 1974, showed Acroneuria sp. to be a common substrate inhabitor. Most specimens were collected from the middle canister level. Bottom samples from Blackmare Creek during the summer, 1974 and previous sampling dates indicated this species was sparse. Canister samples suggest, however, that Acroneuria sp. was a more common streambed inhabitor than bottom samples indicated.

Drift simulation studies showed insect drift increases with increased sedimentation. McClelland (1972) suggested similar results when sediment introductions were made in O'hara Creek in Northern Idaho. As flow increased, sediments saltate along the streambed causing an abrasive force upon benthic life.

Baetis bicaudatus Dodds, a small insect well known for its high propensity to drift, was common in all tributary streams. High spring flows in 1974 were expected to reduce population densities; however, summer bottom samples indicated baetid density had increased or remained at levels previously recorded. This suggests baetid populations were capable of maintaining stability under severe flow and sediment scour conditions. Baetid nymphs collected during the summer, 1974 were of the same middle to late age class as previous summer samples, indicating no phenological difference.

Canister field samples indicated B. bicaudatus generally occupied

the top substrate level during summer stream flows and the hyporheal during the high flows, thus avoiding the sediment scour at the rhithron-water interface. Hynes (1970) reports that several riffle inhabiting nymphs burrow into the gravel to avoid contact with current.

Canisters generally remained in the streambed 6 weeks or more; the winter sample remained approximately 8 months due to limited accessability to the study streams. Sediment accrument and stabilization in the canisters was thought to occur within approximately one month. Bishop (1973) suggested a stabilization period in accruing natural sedimentation for implanted vertical samplers should not exceed 4-8 weeks. It is contended, however, that canister samples should be recovered every 4 weeks if possible, thus obtaining more information relative to insect phenology and vertical migration.

Insect density of many species obtained in the canisters was often too low for definitive evaluation. The low insect densities recovered from canister samples was attributed primarily to the inability to effectively obtain early insect stages.

Insect densities recovered from bottom samples in 1974 were not dramatically reduced from previous summer samples even though tributaries experienced record high spring flows. The benthic communities attained a near normal population density by July, 1974, one month after record high flows. This suggests that benthic communities of the batholith possess a high degree of resiliency, capable of utilizing the substrate to offset population depletion. Many studies have shown that normal high flows cause considerable attrition to insect communities to the commonly sampled rhithron (Elliott, 1965; Bishop and Hynes, 1969; Brusven, 1970 and others). Recolonization of denuded mountain streams,

resulting from high flows, was in the past thought to occur primarily by drifting insects; recolonization of the rhithron is thought to be augmented by insects in the hyporheal.

Basket samples provided an efficient supplementary method of qualitatively comparing insect communities between streams. Ordinal abundance of insects in baskets between streams was generally similar while bottom samples indicated a greater abundance of mayflies, plecoptera and trichoptera, respectively. It is recognized that baskets, because of their structure and sampling position, offer an "optimum" habitat for many aquatic insects, thus resulting in a distribution that differs from the normal in situ community. Burrowing dipterans were generally not recovered from basket samples suggesting the baskets were not suitable habitats for this insect type.

Stream Rehabilitation Practices and Biological Implications.

Streams experiencing high sediment loads occasionally require special rehabilitative measures to restore the river to a productive biological system. Rehabilitation methods are often expensive and have to be carefully weighed with regard to cost-benefit relationships involving short and long-term benefits. Stream rehabilitation is generally recognized as occurring in two forms: 1) instream rehabilitation and 2) watershed rehabilitation. Instream rehabilitation employs techniques as log drop structures, sediment traps, channel diversion, gabion deflectors, debris removal, etc. to aid in the removal of or augmentation of sediments or other pollutants by using the stream's own energy. Watershed rehabilitation is more encompassing and includes rehabilitation of the entire watershed. This latter method of rehabilitation

attempts to arrest the source of the sediment at its source thus inhibiting sediment from entering the stream channel. This method is particularly effective where watersheds have been logged or otherwise disturbed leaving scars of man's activities. Common watershed practices include stablizing road cuts, placing old logging roads and trails to bed, reforestration and reseeding disturbed areas with native vegetation in order to stabilize the surface soils.

This study addressed itself primarily to the effects of sediment and watershed rehabilitation on stream insects with minor inference to terrestrial forms. Stream insects encountered during this study reflected remarkable resilience to a variety of substrate conditions. Populations and communities remained relatively stable through the two diversely different flow years of 1973 and 1974, the latter being one of the highest flood years on record. Greater physical differences occurred as a result of the two diverse flow years than differences resulting from rehabilitation practices in the South Fork Salmon River. It should be pointed out, however, that because of the short duration of the study (3 years) only a short term analysis can be made. When viewing watershed rehabilitation in the broad sense, the full impact can only be measured over a long term period.

Although the study encompassed only 3 years, it was apparent that inherent stream energies were capable of eliminating most unnatural sediment accumulations in the three tributary streams. Unusually high (1974) and low (1973) flows occurred during the study providing a unique opportunity in assessing benthic populations relative to substrate dynamics. Substrate conditions as cobble size, imbeddedness and sediments surrounding cobble were not altered dramatically during

these periods suggesting that over time, near-natural substrate conditions can be maintained unless major sediment producing sources are created. It is viewed that inherent stream energies in conjunction with watershed rehabilitation permitted development of a moderately productive insect community in the test streams.

During this study the physical factors of cobble size, cobble imbeddedness, sediment surrounding cobble and water depth were compared with stream benthos to obtain insect-sediment relationships relative to current rehabilitation practices. The study has shown that insect communities in the South Fork Salmon River are dynamic, capable of adapting to the changing substrate and flow conditions. Study of the hyporheic zone in the South Fork tributaries has demonstrated that aquatic insect communities often inhabit the intersticies below the water-substrate interface. The hyporheic provides a "faunal reserve", a kind of buffer zone which replenishes insect populations temporarily reduced on the streambed surface. Williams and Hynes (1974) report similar findings.

Greater summer-fall insect density fluctuations in Trail and Dollar Creeks when compared to Blackmare Creek suggest streambed stability was not yet attained. Insect densities in Blackmare Creek increased during the study. Arnold and Lundeen (1968) indicated high sediment loads in Trail and Dollar Creeks created streambed instability. Blackmare Creek, uninfluenced by logging and roads is considered to be in a dynamically stable state. Populations fluctuated less dramatically in Blackmare Creek indicating greater stability. It was assumed that sediment loads which affected the streambed of Trail and Dollar Creeks were less stable than Blackmare Creek although stream profiles remained

relatively similar during the study.

Excessive sediments in streams cause adverse effects to most benthic insects consequently effecting higher trophic levels. It is thus imperative that watershed management practices be based on integrated knowledge of ecological systems from which cause and effect relationships can be evaluated. Potential effects of excessive sediment on benthic insects include: reduction or loss of effective habitat; loss and reduction of primary production which serves as the food source of many insects; alteration in normal occurrence of allochthonous organic matter and alteration in interstitial permeability thus influencing respiration.

SUMMARY

This study was initiated to evaluate insect habitats and recolonization capabilities during and after watershed rehabilitation on selected tributary streams of the South Fork Salmon River from 1972-74. Trail and Dollar Creeks were selected because of their history of having been logged and being sediment producers and Blackmare Creek which was pristine. Laboratory investigations were conducted to more definitively evaluate the effects of sediment on insect behavior.

Insect populations and community assemblages serve as useful biological indices for evaluating rehabilitation of heavy sediment-producing streams. Insects serve as the principal fish food of many fishes and their absence or presence and abundance are integral in evaluating the food chain relationships in streams.

Sediment core samples were obtained from tributary streambeds. Dominant materials were gravel and sand; these materials were loose and mobile given proper velocity and discharge. Line transects were established at permanent sites to evaluate streambed profiles over time. Only small changes in streambed profile occurred in 1972 and 1973; larger alterations occurred during the high flows of 1974.

Substrate values were determined for imbeddedness of cobble, cobble size, size of material surrounding cobble and water depth using a sizerank classification scheme. Cobble imbeddedness values were approximately 1/4 for the test tributaries; the condition was not considered detrimental to the endemic aquatic insect communities.

Unusually low and high flows occurred in the tributary streams in

1973 and 1974, respectively; however, only small changes in the substrate parameters of cobble imbeddedness, cobble size, and size of sediment surrounding cobble were evident between years suggesting summer and fall substrate conditions were not adverse for maintenance of a healthy insect community.

Insect density and diversity were highly correlated with parameters of cobble imbeddedness and water depth. An increase in cobble size produced a decrease in insect diversity and density. Creeks with large cobble and boulder substrates were less affected biotically by high flows than habitats having small cobble.

Between year differences in insect communities in the three tributary streams were small. However, Trail and Dollar Creeks had greater seasonal fluctuations in numbers of species than Blackmare Creek suggesting Blackmare Creek had greatest benthic stability. It is probable that Trail and Dollar Creeks are potentially more productive than Blackmare Creek given ample time to fully recover from man-caused disturbances.

Two major emergence periods occurred, mid-June and early September. Both long and short-term life cycles are represented in the insect communities studied.

Insects were recovered from beneath the streambed surface using vertical sampling canisters. Mayflies often dominated the upper and middle levels while stoneflies and caddisflies were generally dominant in the lower strata. Insect populations inhabiting the canisters demonstrated seasonal fluctuations; however, the fluctuations were attributed more to temporal effects of insect development than sediment accrument. Canister simulation showed Acroneuria sp. responded

to surface movement of sediments by migrating deep into the substrate. A similar response was recorded in the field.

Summer insect density in 1974 was not dramatically reduced after record high flows. The tributaries, especially Blackmare Creek, were capable of maintaining near normal population levels equivalent to 1973. Mayflies were the most abundant benthic insects.

Hyporheic distribution of many insects provided a "faunal reserve," which serves to hasten recolonization. Substrate permeability and sediment composition of the hyporheil influence the kind and amount of insect colonization.

Insect drift was similar for 1972 and 1974. Unusually low flows of 1973 resulted in low insect drift. Drift simulation studies showed insect drift increased with increased sedimentation.

Basket samples indicated little variation among insect communities between streams. Dipterans did not readily colonize the basket samplers.

Substrate parameters of cobble, size, cobble imbeddedness and sediment surrounding cobble did not vary appreciably, for a given site during the summer and fall months, suggesting that near steady-state conditions can be maintained by normal stream energy unless new and major sediment sources are created.

Watershed rehabilitation was implemented on the South Fork and certain tributary drainages to retard sediment introduction into streambeds. Above average discharges since 1969 have provided energies sufficient for high sediment removal. Watershed rehabilitation is viewed as having greater practicality and long-term stabilizing effects than instream rehabilitation in the South Fork Salmon River tributaries.

We conclude the high and low flow years of 1973 and 1974 had a greater effect on streambed conditions than the short-term rehabilitation effects monitored during this study.

RECOMMENDATIONS

The following recommendations pertain to the South Fork Salmon River drainage and are the result of research conducted on selected tributaries of that drainage:

Aquatic insects be used as standard indicators of stream perturbation in South Fork Salmon River tributaries. Aquatic insects by virtue of their distribution, mobility and habitat specificity serve as some of the most useful organisms for reflecting benthic productivity and general streambed conditions.

Maintain sampling stations on tributary streams of the South Fork of the Salmon River for purpose of monitoring subsequent benthic insect-streambed changes; further recommend that the anadromous fishery be monitored in principal tributaries.

Continue annual sampling of benthic insects in South Fork Salmon River tributaries on an annual basis to reflect long-term rehabilitation effects.

Standard Hess bottom sampler, vertical sampling canisters, drift nets and sampling baskets be maintained as standard sampling methods for assessing insect communities. These techniques allow for both surface and subsurface evaluation of insect community structure.

Flow gauging stations be established on Trail, Dollar and Blackmare Creeks to provide data on flow conditions and sediment transport on a monthly, seasonal and annual basis. These physical measurements are integral in evaluating insect-substrate relationships.

Watershed rehabilitation, involving arresting of sediments at the sediment source, be undertaken in preference to instream rehabilitation. Inherent sediment transport capacity of moderate to high gradient tributaries of the South Fork Salmon River is considered sufficient to remove excess sediment burden during most normal or above normal flow years.

Conduct fish food habit studies in order to determine the role and importance of different kinds of insects in the food chain.

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Appendix A

Checklist and Ranked Abundance of Aquatic Insects in Bottom Samples, Sampling Baskets and Canisters at Trail Creek for Summer and Fall, 1972-74.[a]

Species	Basket	Canister	Bottom Samples											
			T-1						T-2					
			1972		1973		1974		1972		1973		1974	
			S	F	S	F	S	F	S	F	S	F	S	F
Ephemeroptera														
Ameletus sp.	*	*	r	a	s	r	r	s	s	c	s	s	r	s
Baetis bicaudatus Dodds	*	*	s	c	a	c	c	s	c	s	c	s	a	s
Baetis parvus Dodds											r			
Baetis tricaudatus Dodds	*		s	s	r			r	r	r	r	r	r	r
Centroptilum sp.		*												r
Cinygmula sp.	*	*	c	r	a	s	a	s	c	c	a	r	a	s
Epeorus albertae (McDun.)	*		r	s	r	c	s	s	s	r		s	c	s
Epeorus grandis (McDun.)				c	r				r		r			
Epeorus longimanus (Eaton)		*	s		c	s			s		c		s	
Ephemerella doddsi Needham	*	*	r	a	r	c		c	r	c	r	c	r	s
Ephemerella edmundsi Allen	*		r	r		r	r	c		r		r		
Ephemerella flavilinea (McDun)					s	r	r		r	s		r	r	r
Ephemerella grandis Eaton								r			r	s		
Ephemerella hystrix Traver	*			c	r	s						c		
Ephemerella inermis Eaton	*	*				s		r	r		r	c		r
Ephemerella infrequens Eaton				c		r				s	r	s		
Ephemerella spinifera Needham	*	*	r	a	s	c	r	a	r	s	r	s	r	r
Ephemerella teresa Traver			r						r					
Ephemerella tibialis (McDun.)	*	*			s	r	s	s	r		s		s	r
Paraleptophlebia heteronea (McDun.)	*	*		c		s		r		s		s		
Rhithrogena hageni Eaton	*	*	s	a	c	s	s	s	s	a	s		c	
Rhithrogena robusta Dodds		*						s			r	a	r	c
Plecoptera														
Acroneuria californica (Banks)	*	*		s	r	r	r	r	r	r	r	r	r	r
Alloperla sp.	*	*	r	c	s	c	s	c	s	s	c	c		s
Arcynopteryx sp.	*			s			r		r	r		r	r	r
Brachyptera sp.	*	*								r	r			
Capnia sp.														
Isogenus sp.	*	*		r	r	c	s	s	s	s	r	c	s	s
Leuctra sp.		*						r		r	r	r	r	r
Nemoura sp.	*	*		c	r	s	r	s	s	r	r	s	r	r
Paraperla frontalis (Claassen)			r	r	r			r		r	r	r		
Peltoperla sp.			r	r	r	r	r	r					s	

Species	Basket	Canister	Bottom Samples T-1 1972 S	T-1 1972 F	T-1 1973 S	T-1 1973 F	T-1 1974 S	T-1 1974 F	T-2 1972 S	T-2 1972 F	T-2 1973 S	T-2 1973 F	T-2 1974 S	T-2 1974 F
Trichoptera														
Arctopsyche grandis (Banks)	*	*									r	s	r	
Brachycentrus sp.	*								r		r			
Dicosmoecus sp.	*										r			r
Drusinus sp.	*			r				r		r				r
Ecclisomyia sp.										r				
Glossosoma sp.	*	*		c		r				r		r		
Hydroptilidae												r		
Lepidostoma sp.		*	r											
Limnephilidae	*													
Micrasema sp.	*	*	s	s	s	c	r	r		r		s	r	r
Neophylax sp.	*	*			r			s	r	r		r		
Neothremma sp.	*								s					
Parapsyche elsis Milne	*	*	r	s		r		r	r	r		s		
Rhyacophilia acropedes Banks	*	*		s	r	s	r	s	r	r	r	s	s	r
Rhyacophila angelita Banks		*	s	r	r		r	s	r	r	s	r	s	s
Rhyacophila hyalinata Banks	*			r					r					
Rhyacophila tucula Ross														
Rhyacophila vaccua Milne	*	*	r		s	s		r	r		s	r	r	
Rhyacophila vepulsa Milne		*	r	s		s	s	c		s	r	s	r	c
Rhyacophila verrula Milne			s		r						r		r	
Sortosa sp.	*	*		r		a		s				r		
Wormaldia sp.														
Diptera														
Antocha sp.	*								r		r	r		s
Blephariceridae		*												
Ceratopogonidae		*	r	r		r	r	s	r	r	r	s	r	s
Chironomidae	*	*		s	s	a	r	c	r	r	c	a	s	s
Dicranota sp.		*			s	r					s	r	r	r
Dixa sp.														
Empididae		*	r		r	r					r			
Ephidridae														
Hexatoma sp.		*			r	s	r	r	r	r	r	s	r	
Limnophila sp.		*		r			r	r		r				r
Prosimulium sp.									r		r			
Psychodidae				r						r		r		
Ptychopteridae														
Rhabdomastix sp.			r				r		r		r	r	r	
Simulium sp.	*	*		r		r		r	r		r	r	r	
Tipula sp.		*								r	r	r	r	r
Weidemannia sp.			r	r	r					r				
Coleoptera														
Amphizoidae														
Dytiscidae								r				r		
Heterlimnius corpulentus (LeConte)	*	*	s	c	c	a	c	c	r	s	s	c	s	c
Hydrophilidae														
Lara sp.														

Species	Basket Canister	Bottom Samples											
		T-1						T-2					
		1972		1973		1974		1972		1973		1974	
		S	F	S	F	S	F	S	F	S	F	S	F
Coleoptera (cont.)													
Narpus sp.					r		r				r		
Optioservus seriatus (LeConte)									r				

[a]a = abundant (>51 insects); c = common (21-50 insects); r = rare (1-5 insects); s = sparse (6-20 insects) based on number of insects collected at Trail Creek.

T-1 = Station 1, T-2 = Station 2.

* Insects present.

Appendix B

Checklist and Ranked Abundance of Aquatic Insects in Bottom Samples, Sampling Baskets and Canisters at Dollar Creek for Summer and Fall of 1972-74.[a]

Species	Basket	Canister	Bottom Samples											
			D-3						D-4					
			1972		1973		1974		1972		1973		1974	
			S	F	S	F	S	F	S	F	S	F	S	F
Ephemeroptera														
Ameletus sp.	*	*	r	r	r	r		s	r	s		c	s	c
Baetis bicaudatus Dodds	*	*	c	c	a	a	a	c	c	s	a	c	c	s
Baetis parvus Dodds														r
Baetis tricaudatus Dodds	*	*	s	s					r	s		r		
Centroptilum sp.		*				s						r		
Cinygmula sp.		*	s		a	r	a	r	c		c	r	a	
Epeorus albertae (McDun.)	*		s	r		a	c	c	r			c	c	s
Epeorus grandis (McDun.)	*		s	c	r			c	r	s		r		
Epeorus longimanus (Eaton)		*	r		a		r				c		r	
Ephemerella doddsi Needham	*	*	r	s	r	s	r	c	r	s	s	c		c
Ephemerella edmundsi Allen	*			s	r	r		s	r	r	r			r
Ephemerella flavilinea (McDun.)	*		r		s	r	r	r	r		r	r	r	r
Ephemerella grandis Eaton												r		
Ephemerella hystrix Traver	*			c		a	r			s		s		
Ephemerella inermis Eaton	*	*			s	s			r	r	r	s		s
Ephemerella infrequens Eaton				c		s	r	s		s	r	r		
Ephemerella spinifera Needham	*			s	r	s		s	r	r		s	r	s
Ephemerella teresa Traver														
Ephemerella tibialis(McDun)	*	*			s	r	s		s		s	s	s	r
Paraleptophlebia heteronea (McDun.)	*	*		r		s		r		s		c		s
Rhithrogena hageni Eaton	*	*	s	a	c	r	c		s	a	c		s	
Rhithrogena robusta Dodds	*	*			s	a	r	a			r	a		c
Plecoptera														
Acroneuria californica (Banks)	*	*	r	s	r	r	r	s	r	s	r	r	r	s
Alloperla sp.	*		r	s	r	s	s	r	r	r	r	s	r	r
Arcynopteryx sp.	*		r	s	r	s	s	r	r	r	r	s	r	r
Brachyptera sp.	*	*		s	r					s				
Capnia sp.								r						r
Isogenus sp.	*	*		r	s	c	s	r	r	r	s	c	s	s
Leuctra sp.		*	r	r	s	s		r	r	r	r	r	r	r
Nemoura sp.	*	*	s	c	c	s	s	s	s	c	r	c	r	r
Paraperla frontalis Claassen)		*	r		r	r	r			r	r	r		
Peltoperla sp.						r	r				r	r		

Species	Basket	Canister	Bottom Samples D-3 1972 S	D-3 1972 F	D-3 1973 S	D-3 1973 F	D-3 1974 S	D-3 1974 F	D-4 1972 S	D-4 1972 F	D-4 1973 S	D-4 1973 F	D-4 1974 S	D-4 1974 F
Trichoptera														
Arctopsyche grandis (Banks)	*	*		s		s				s	r	c		r
Brachycentrus sp.	*			r		s				r		r		
Dicosmoecus sp.			r						r			r		
Drusinus sp.	*							r						r
Ecclisomyia sp.														
Glossosoma sp.	*	*			r	r				r	r	s		
Hydroptilidae														
Lepidostoma sp.	*	*												
Limnephilidae														
Micrasema sp.	*	*		c	s	a	r	s	r	r	s	s	r	r
Neophylax sp.	*	*		r	r	c						s		
Neothremma sp.	*		r	c		s			r	s		s	r	s
Parapsyche elsis Milne	*	*	r	r	r	c	r	r	r	r	r	s	r	
Rhyacophila acrepedes Banks	*	*	r	s	s	r	r	s	s	s	r	c	r	r
Rhyacophila angelita Banks	*	*	r	r	s	r	s	s	r	r	s	s	s	s
Rhyacophila hyalinata Banks	*		r	r		r			r	r		r		
Rhyacophila tucula Ross														
Rhyacophila vaccua Milne	*	*	r		r	s	r	r	r	r	s	s	r	r
Rhyacophila vepulsa Milne	*	*	r	s	r	s	s	c	r	s	r	s	r	c
Rhyacophila verrula Milne							r	r						r
Sortosa sp.	*			s		s		r		r		s		
Wormaldia sp.														
Diptera														
Antocha sp.							r				r			
Blephariceridae														
Ceratopogonidae		*				r	r	r				s		
Chironomidae	*	*	r	r	r	a	r	s	s	r	s	c	c	c
Dicranota sp.		*			r	r					s	r	r	r
Dixa sp.														
Empididae														r
Ephidridae														
Hexatoma sp.		*		r	s	s	r	r	r	r		c	r	s
Limnophila sp.		*					r	r	r	r	r	s	r	r
Prosimulium sp.				s		r	r							
Psychodidae										r		r		
Ptychopteridae														
Rhabdomastix sp.			r		r						r	r		
Simulium sp.	*	*			r	s	r	r	r		r	r	r	
Tipula sp.		*			r	s	r		r		r	s	r	s
Weidemannia sp.										r				
Coleoptera														
Amphizoidae														
Dytiscidae												r		r
Heterlimnius corpulentus (LeConte)	*	*		s	r	s	r	s	r	s	r	a	s	s
Hydrophilidae														
Lara sp.	*													
Narpus sp.														

Species	Basket Canister	Bottom Samples											
		D-3						D-4					
		1972		1973		1974		1972		1973		1974	
		S	F	S	F	S	F	S	F	S	F	S	F
Coleoptera (cont.)													
Optioservus seriatus (LeConte)									r				

[a]a = abundant (>51 insects); c = common (21-50 insects); r = rare (1-5 insects); s = sparse (6-20 insects) based on number of insects collected at Dollar Creek.

D-3 = Station 3, D-4 = Station 4.

* Insects present.

Appendix C

Checklist and Ranked Abundance of Aquatic Insects in Bottom Samples, Sampling Baskets and Canisters at Blackmare Creek for Summer and Fall of 1972-1974.[a]

Species	Basket	Canister	Bottom Samples B-5 1972 S	B-5 1972 F	B-5 1973 S	B-5 1973 F	B-5 1974 S	B-5 1974 F	B-6 1972 S	B-6 1972 F	B-6 1973 S	B-6 1973 F	B-6 1974 S	B-6 1974 F
Ephemeroptera														
Ameletus sp.	*	*	r	a	r	c	r	s	r	c	r		r	r
Baetis bicaudatus Dodds	*	*	a	c	a	a	a	a	a	s	a	a	a	a
Baetis parvus Dodds												r		
Baetis tricaudatus Dodds	*	*	r							c	r			
Centroptilum sp.														
Cinygmula sp.	*	*	a	r	c	c	a	s	c	r	c	s	a	s
Epeorus albertae (McDun.)	*		s			a	c	a	s	s	r	c	c	a
Epeorus grandis (McDun.)			r	a			r	s	s	s	r			a
Epeorus longimanus (Eaton)		*	r	r	a		s		s		a		s	
Ephemerella doddsi Needham	*		r	c	s	s		c	r	c	c	c	r	c
Ephemerella edmundsi Allen					r			r			r			r
Ephemerella flavilinea (McDun.)			s		s	r	s	r	s		c		c	s
Ephemerella grandis Eaton	*	*				c						c		
Ephemerella hystrix Traver				s		r	r		r	c			r	
Ephemerella inermis Eaton	*	*			r	s	r	s				s		s
Ephemerella infrequens Eaton				c						c	r			
Ephemerella spinifera Needham	*		r	r	r	r	r	r		s	r	r	r	r
Ephemerella teresa Traver			s						r					
Ephemerella tibialis (McDun.)	*	*	r		r	c	s	s	s		s	s	c	r
Paraleptophlebia heteronea (McDun.)	*	*		r	r	s		r				r		r
Rhithrogena hageni Eaton	*	*	s	a	s		r		s	a	s		s	
Rhithrogena robusta Dodds	*	*				c		a			r	a	s	a
Plecoptera														
Acroneuria californica (Banks)	*	*	r	s	r	r	r	c	r	s	r	s		s
Alloperla sp.	*	*	r	s	s	c	s	s	s	s	s	s	r	s
Arcynopteryx sp.	*	*	s	s		r	r	s	r	s		r	r	s
Brachyptera sp.	*	*		a						a				
Capnia sp.	*	*						s						s
Isogenus sp.		*	r	r	s	c	s	r	r		s	c	c	r
Leuctra sp.		*		r		r		r	r		s	s	r	r
Nemoura sp.	*	*	c	c	r	c	s	s	s	a	s	s	s	r
Paraperla frontalis (Claassen)					r		r		r					
Peltoperla sp.			r	r				r			r	r	r	

Species	Basket	Canister	Bottom Samples B-5 1972 S	B-5 1972 F	B-5 1973 S	B-5 1973 F	B-5 1974 S	B-5 1974 F	B-6 1972 S	B-6 1972 F	B-6 1973 S	B-6 1973 F	B-6 1974 S	B-6 1974 F
Trichoptera														
Arctopsyche grandis Banks)	*	*		r		s		r		r		s		
Brachycentrus sp.				r		r			r	r	r	r		
Dicosmoecus sp.	*													
Drusinus sp.														
Ecclisomyia sp.														
Glossosoma sp.				r						r				
Hydroptilidae														
Lepidostoma sp.														
Limnephilidae														
Micrasema sp.	*	*			r		s	c		r	r		s	s
Neophylax sp.				s		r	r	r		s		s		r
Neothremma sp.	*	*	r	r		r				s				
Parapsyche elsis Milne	*	*				r	r	r	r	r		s	r	r
Rhyacophila acropedes (Banks)	*	*	s	s	r	s	s	r	r	s	s	s	s	r
Rhyacophila angelita Banks			r	r	c	r	s	s	r	r	c	r	a	c
Rhyacophila hyalinata Banks			r	r		r			r	s		r		
Rhyacophila tucula Ross					r									
Rhyacophila vaccua Milne	*	*	r	s	s	c	s	r	r	s	s	c	r	s
Rhyacophila vepulsa Milne	*	*		s	r	c	r	s		r	r	s	r	s
Rhyacophila verrula Milne							r				r		r	r
Sortosa sp.		*		r		s		r		r		c		r
Wormaldia sp.		*												
Diptera														
Antocha sp.	*		r			r						r		
Blephariceridae														
Ceratopogonidae		*	r	r		r		r				r	r	r
Chironomidae	*	*	s	s	c	a	s	c	s	s	a	a	c	c
Dicranota sp.	*	*			s	r	r	r			s	r	r	r
Dixa sp.		*												
Empididae						r					r	r		
Ephidridae														
Hexatoma sp.		*			r			r		r	r	r	r	r
Limnophila sp.		*		r		r		r				r		r
Prosimulium sp.				r	r									
Psychodidae														
Ptychopteridae														
Rhabdomastix sp.					r	r								
Simulium sp.	*	*			r	r	r		r		r	r	r	r
Tipula sp.		*				r		r				r		r
Weidemannia sp.				r		r			r					
Coleoptera														
Amphizoidae														
Dytiscidae														
Heterlimnius corpulentus (LeConte)	*	*		s	s	c	s	s	r	s	c	c	s	c
Hydrophilidae														
Lara sp.						r								

Species	Basket Canister	Bottom Samples											
		B-5						B-6					
		1972		1973		1974		1972		1973		1974	
		S	F	S	F	S	F	S	F	S	F	S	F
Coleoptera (cont.)													
Narpus sp.						r	r						
Optioservus seriatus (LeConte)										r	r		

[a]a = abundant (>51 insects); c = common (21-50 insects); r = rare (1-5 insects); s = sparse (6-20 insects) based on number of insects collected at Blackmare Creek.

B-5 = Station 5, B-6 = Station 6.

* Insects present.

Appendix D

Community similarity of upper stations (Trail 1, Dollar 3, Blackmare 5) for summer and fall samples, 1972-74.

Summer	Trail Creek			Dollar Creek			Blackmare Creek		
	'72	'73	'74	'72	'73	'74	'72	'73	'74
Trail Cr. 1972		.42	.39	.54	.38	.42	.38	.37	.40
Trail Cr. 1973			.60	.42	.48	.38	.38	.40	.43
Trail Cr. 1974				.57	.48	.42	.51	.47	.51
Dollar Cr. 1972					.58	.56	.54	.53	.65
Dollar Cr. 1973						.66	.52	.59	.67
Dollar Cr. 1974							.54	.53	.57
Blackmare Cr. 1972								.55	.51
Blackmare Cr. 1973									.51
Blackmare Cr. 1974									

Fall	Trail Creek			Dollar Creek			Blackmare Creek		
	'72	'73	'74	'72	'73	'74	'72	'73	'74
Trail Cr. 1972		.65	.67	.54	.44	.54	.56	.54	.52
Trail Cr. 1973			.61	.52	.55	.59	.61	.73	.57
Trail Cr. 1974				.50	.50	.53	.56	.57	.63
Dollar Cr. 1972					.55	.65	.64	.48	.53
Dollar Cr. 1973						.59	.65	.60	.61
Dollar Cr. 1974							.70	.60	.69
Blackmare Cr. 1972								.72	.77
Blackmare Cr. 1973									.71
Blackmare Cr. 1974									

Appendix E

Interstream comparisons of lower stations (Trail 2, Dollar 3, Blackmare 6) for summer and fall samples, 1972-74.

Summer	Trail Creek			Dollar Creek			Blackmare Creek		
	'72	'73	'74	'72	'73	'74	'72	'73	'74
Trail Cr. 1972		.59	.62	.54	.58	.47	.64	.56	.51
Trail Cr. 1973			.69	.43	.64	.52	.53	.52	.53
Trail Cr. 1974				.46	.64	.58	.50	.48	.53
Dollar Cr. 1972					.66	.54	.62	.58	.62
Dollar Cr. 1973						.70	.62	.56	.69
Dollar Cr. 1974							.53	.56	.66
Blackmare Cr. 1972								.69	.72
Blackmare Cr. 1973									.77
Blackmare Cr. 1974									

Fall	Trail Creek			Dollar Creek			Blackmare Creek		
	'72	'73	'74	'72	'73	'74	'72	'73	'74
Trail Creek 1972		.61	.51	.56	.57	.43	.58	.49	.57
Trail Creek 1973			.66	.54	.61	.47	.40	.47	.49
Trail Creek 1974				.51	.52	.42	.37	.36	.44
Dollar Creek 1972					.73	.57	.54	.51	.62
Dollar Creek 1973						.61	.55	.56	.63
Dollar Creek 1974							.52	.56	.65
Blackmare Creek 1972								.63	.65
Blackmare Creek 1973									.69
Blackmare Creek 1974									

Appendix F

Community similarity between upper and lower stations of tributary creeks for summer and fall samples, 1972-74.

Summer	'72	'73	'74
Trail Creek	.42	.43	.47
Dollar Creek	.52	.65	.45
Blackmare Creek	.53	.55	.56

Fall	'72	'73	'74
Trail Creek	.43	.57	.47
Dollar Creek	.52	.57	.51
Blackmare Creek	.68	.58	.65

Appendix G

Checklist and Ranked Abundance of Aquatic Insects at "faunistic" sites (Dollar Creek) during fall of 1972 and summer and fall of 1973-74.[a]

	Bottom Samples				
	1972	1973		1974	
Species	F	S	F	S	F
Ephemeroptera					
Ameletus sp.	r	r	r	r	r
Baetis bicaudatus Dodds	r	c	s	c	c
Baetis parvus Dodds					
Baetis tricaudatus Dodds	c		a	r	
Centroptilum sp.					
Cinygmula sp.	c	c	s	c	s
Epeorus albertae (McDun.)	a		a	a	c
Epeorus grandis (McDun.)	c		s		c
Epeorus longimanus (Eaton)		s		r	
Ephemerella doddsi Needham	c	c	a	s	c
Ephemerella edmundsi Allen		r	r		r
Ephemerella flavilinea (McDun.)	r	r	r	r	r
Ephemerella grandis Eaton					
Ephemerella hystrix Traver	r	r	c	s	
Ephemerella inermis Eaton	r		c	r	s
Ephemerella infrequens Eaton		r			
Ephemerella spinifera Needham	r	r	c	s	s
Ephemerella tibialis (McDun.)	r		r	r	r
Paraleptophlebia heteronea (McDun.)			s		r
Rhithrogena hageni Eaton	c	r	a		
Rhithrogena robusta Dodds		r		a	a
Plecoptera					
Acroneuria californica (Banks)	r		s	r	s
Alloperla sp.	r	r	c	s	s
Arcynopteryx sp.	s	r	c	s	s
Brachyptera sp.	r		r		
Capnia sp.					r
Isogenus sp.	r	r	r	r	r
Leuctra sp.	r	r	r	r	r
Nemoura sp.	s	s	c	s	s
Paraperla frontalis (Claassen)	r	s	r		
Peltoperla sp.	r	r	r	r	r
Trichoptera					
Arctopsyche grandis (Banks)			r	r	r
Brachycentrus sp.		r	c		
Dicosmoecus sp.			r		
Drusinus sp.				r	
Ecclisomyia sp.					
Glossosoma sp.			s		

Species	Bottom Samples 1972 F	1973 S	1973 F	1974 S	1974 F
Trichoptera (cont.)					
Hydroptilidae				r	r
Lepidostoma sp.		r	r		
Limnephilidae					
Micrasema sp.		r	s	c	s
Neophylax sp.			r	r	r
Neothremma sp.	s	s	c	s	c
Parapsyche elsis Milne	r	r	c	r	c
Rhyacophila acropedes Banks	s	r	c	s	s
Rhyacophila angelita Banks	r	s	s	s	s
Rhyacophila hyalinata Banks	r	r	s		
Rhyacophila tucula Ross					
Rhyacophila vaccua Milne	r	r	c	r	r
Rhyacophila vepulsa Milne	r	r	c	s	s
Rhyacophila verrula Milne	r			r	r
Sortosa sp.	r		s	r	c
Wormaldia sp.					
Diptera					
Antocha sp.			r		
Blephariceridae					
Ceratopogonidae			r	r	r
Chironomidae	r	r	a	s	s
Dicranota sp.	r	r	r		
Dixa sp.					
Empididae	r	r	r		r
Ephidridae					
Hexatoma sp.	r	r	r	r	r
Limnophila sp.		r	r	r	r
Prosimulium sp.					
Psychodidae					
Ptychopteridae					
Rhabdomastix sp.					
Simulium sp.	r	r	r	r	r
Tipula sp.	r		r	r	r
Weidemannia sp.	r	r	r		
Coleoptera					
Amphizoidae					
Dytiscidae					
Heterlimnius corpulentus (LeConte)	r	r	s	r	r
Hydrophilidae					
Lara sp.					r
Narpus sp.					
Optioservus seriatus (LeConte)	r				

[a] a = abundant (>51 insects); c = common (21-50 insects); r = rare (1-5 insects); s = sparse (6-20 insects) based on number of insects collected at Dollar Creek.

Appendix H

Checklist and Ranked Abundance of Drifting Insects per net at Trail and Blackmare Creeks in 1972-74.[a]

Species	Trail Cr.			Blackmare Cr.		
	1972	1973	1974	1972	1973	1974
Ephemeroptera						
Ameletus sp.	c	s	a	s	s	r
Baetis bicaudatus Dodds	c	s	a	a	s	a
Baetis tricaudatus Dodds	a	a	r	a	a	r
Cinygmula sp.	c	r	c	s	r	s
Epeorus albertae (McDunnough)	a	c	a	c	c	a
Epeorus grandis (McDunnough)	a	s		a	c	c
Epeorus longimanus (Eaton)	c			s	r	
Ephemerella doddsi Needham	r	r		r	r	
Ephemerella edmundsi Allen	r	r	r	r	r	
Ephemerella flavilinea McDunnough	r			r		s
Ephemerella grandis Eaton		r	a		r	
Ephemerella hystrix Traver	r	s			s	
Ephemerella inermis Eaton		r			s	r
Ephemerella infrequens Eaton				r		
Ephemerella spinifera Needham	r		s	r	r	
Ephemerella tibialis McDunnough	a	s	a	c	r	a
Paraleptophlebia heteronea (McDunnough)	r	r		r		
Rhithrogena hageni Eaton	c	c		s	s	
Rhithrogena robusta Dodds			a			r
Plecoptera						
Acroneuria californica (Banks)	r	r	r		r	r
Alloperla sp.	s	r	c	s	r	s
Arcynopteryx sp.	c	s	s	r	r	s
Capnia sp.	r			r	r	
Isogenus sp.	c	r	c	r	r	s
Nemoura sp.	a	s	c	c	s	a
Peltoperla sp.	r		r	r		r
Trichoptera						
Arctopsyche grandis (Banks)		r		r	r	
Brachycentrus sp.	r	r		r	r	r
Dicosmoecus sp.			r			
Drusinus sp.	r		r	r	r	r
Glossosoma sp.		r		r		r
Hydroptilidae						r
Lepidostoma sp.	r	r	c			r
Limnephilidae	r	r	c	r	r	r
Micrasema sp.	s	r	s	r	r	s
Neothremma sp.	r		r	r	r	r
Parapsyche elsis Milne	r		r	r	r	r

Species	Trail Cr. 1972	1973	1974	Blackmare Cr. 1972	1973	1974
Trichoptera (cont.)						
Rhyacophila acropedes Banks	s	r	c	r	s	s
Rhyacophila angelita Banks					r	
Rhyacophila hyalinata Banks				r	r	
Rhyacophila vaccua Milne			r	r		r
Rhyacophila vepulsa Milne	r		r		r	
Rhyacophila verrula Milne			s			s
Sortosa sp.		r	r	r	s	r
Diptera						
Ceratopogonidae			r			
Chironomidae	r	a	s	r	c	r
Dixa sp.			r			
Empididae				r	r	
Hexatoma sp.	r					
Limnophila sp.						
Ptychopteridae			r			
Simulium sp.	s	c	s	s	c	s
Coleoptera						
Amphizoidae			r			
Dytiscidae	r		r	r	r	
Heterlimnius corpulentus (LeConte)		s	s	r	s	r
Hydrophilidae	r		r			
Lara sp.				r	r	
Narpus sp.	s		r	r	r	r
Optioservus seriatus (LeConte)	c	s		r	r	r

[a]a = abundant (>51 insects); c = common (21-50 insects); r = rare (1-5 insects); s = sparse (6-20 insects) based on number of insects collected at Trail and Blackmare Creeks.